2

31952
Int.
24444
Pat. 43

Cassier's Magazine

Engineering Illustrated

Volume XXXII

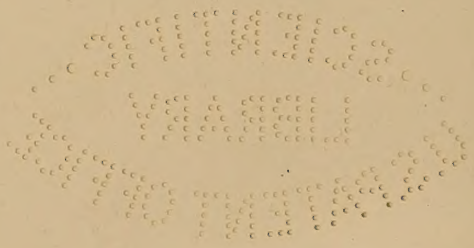
May—October, 1907

The Cassier Magazine Company
3 West 29th St., New York
33, Bedford Street, Strand, London

85605

TA1
C34

Copyright by the
CASSIER MAGAZINE CO.,
1907



INDEX TO VOLUME XXXII.

		PAGE
Aerial Cable Construction for Telephone Exchange, Illustrated.	C. W. Burkett,	216
Air Compressors, Multiple Turbine,		372
American Fleet from an English Point of View, The, Illustrated.	Archibald S. Hurd,	467
Applications of Special Tools,		464
Ashworth, James: Coal Dust Explosions in Collieries, Illustrated.		478
Wingate Grange Colliery Explosion, Illustrated.		478
Autogeneous Welding, Illustrated.	F. C. Cutler,	441
Baron, Louis: Biography of Adolph Bender,		287
Baron, Harold: Incandescent Gas Mantles, Illustrated.		195
Barrus, George H.: Fuel Losses in Steam Power Plants,		321
Battleships, Docks for Large,		368
Bayles, James C.: The Manufacture of Steel Rails,		195
Beginning of Steam Navigation, William Symington and the, Illustrated.	Robert Cochrane,	525
Behrend, B. A.: The Coming of Age of Electrical Engineering, Illustrated.		42
Belmont Tunnel in New York, The, Illustrated.	H. H. Kress,	364
Benjamin Chas. R.: Lifting Magnets, Illustrated.		544
Bessemer Converter, The Dry Blast in the,		283
BIOGRAPHIES:		
Jacobus, David Schenck,		95
Saunders, William Lawrence,		191
Bender, Adolph,		194
Chesney, Cummings C.,		376
Barrett, John,		559
Birkinbine, John: Iron Ore Reserves of the United States, Illustrated.		99
Boiler Practice, Efficiency in Steam, Illustrated.	Percival Cooke,	47, 106
Boiler-Room Design and Equipment, Illustrated.	Wm. H. Bryan,	448
Bolsover, H. W.: The Flash Steam Generator, Illustrated.		427
Bowker, William R.: The Law of Economical Proportion as Applied to Tramway Rolling Stock,		140
Breakages of Steel Rails, Illustrated.	Robert Job,	66
Brelich, Henry: Native Methods of Mining and Smelting Quicksilver Ore in Kweichow, China, Illustrated.		127
Brennan Monorail, The,		284
British Naval Programme, The,		189
British Tank Locomotives, Illustrated.	J. R. Thompson,	357
Brown, C. Vesey: Electric Power Tariffs, Illustrated.		304
Bryan, Wm. H.: Boiler Room Design and Equipment, Illustrated.		448
Bunnell, Sterling H.: The Speed Regulation of Steam Engines, Illustrated.		505
Burkett, C. W.: Aerial Cable Construction for Telephone Exchange, Illustrated.		216
By Products, Utilization of,		372
Cable Construction for Telephone Exchanges, Aerial, Illustrated.	C. W. Burkett,	216
Calisch, Lionel: Recent Progress in Electric Incandescent Lamps,		354
Car, A Swedish Railway Motor,		285
Costings, Higher,	Arthur Winder,	517
Central Station and the Isolated Plant, The,	H. S. Knowlton,	359

		PAGE
Centres of Engineering Association,		93
China, Native Methods of Mining and Smelting Quicksilver Ore in Kweichow, Illustrated.	Henry Brelich,	127
Christie, William Wallace: Safety Appliances in the Engine Room, Illustrated.		333
Civilian Inventors,		463
Coal Dust Explosions in Collieries, Illustrated.	James Ashworth,	478
Cochrane, Robert: William Symington and the Beginning of Steam Navigation, Illustrated.		525
College Graduates, Employment of.		283
Colliery Explosion, Wingate Grange, Illustrated.	James Ashworth,	478
Collieries, Coal Dust Explosions in, Illustrated.	James Ashworth,	478
Coming of Age of Electrical Engineering, The, Illustrated.	B. A. Behrend,	42
Congestion, Municipal Traffic,		374
Construction for Telephone Exchanges, Aerial Cable, Illustrated.	C. W. Burkett,	216
Compressors, Multiple Turbine Air,		372
Cooke, Percival: Efficiency in Steam Boiler Practice, Illustrated.		47, 106
Cost Finding, Practical,		371
Cost, Industrial Legislation and Its,	T. Good,	209
Coming of Age of Electrical Engineering, Illustrated.	B. A. Behrend,	42
Cruise of the Dreadnought, The Trial,		187
Cutler, F. C.: Autogeneous Welding, Illustrated.		441
Development of the Elevator Industry, The Growth and, Illustrated.	C. H. Kloman,	389
Development of New York City, The Rock Drill and Its Share in, Illustrated.		160
Developments in Germany, Naval,		370
Developments in Machine Tools, Some Recent, Illustrated.	Joseph Horner,	263, 312
Distribution of Shop Expense, The,		517
Docks for Large Battleships,		368
Dreadnought, Trial Cruise of the,		187
Dry Blast in the Bessemer Converter, The,		283
Early Steamboats,		554
Economical Proportion as Applied to Tramway Rolling Stock, The Law of,	William R. Bowker,	140
Efficiency in Steam Boiler Practice, Illustrated.	Percival Cooke,	47, 106
Elevator Industry, The Growth and Development of the, Illustrated.	Charles H. Kloman,	389
Electrical Engineering, The Coming of Age of, Illustrated.	B. A. Behrend,	42
Electric Incandescent Lamps, Recent Progress in,	Lionel Calisch,	354
Electric Power Tariffs, Illustrated.	C. S. Vesey-Brown,	304
Electrometallurgical Industries in 1907, The, Illustrated.	John B. C. Kershaw,	26
Employees, The Promotion of,	J. F. Gairns,	420
Employment of College Graduates,		283
Engines, The Speed Regulation of Steam, Illustrated.	Sterling H. Bunnell,	505
Engineering Societies Building in New York, Illustrated.		12
Engineering, The Coming of Age of Electrical, Illustrated.	B. A. Behrend,	42
England, Municipal Ownership in,	R. S. Hale,	3, 178, 237
Equipment, Boiler Room Design and, Illustrated.	Wm. H. Bryan,	448
Engineering, Marine and Naval,		94
Energy Problem of the Universe, The,	A. H. Gibson,	379
Engineering Association, Centres of,		93

		PAGE
Engineering Efficiency,		94
Expense, Distribution of Shop,	Arthur Winder,	517
Explosions in Collieries, Coal Dust, Illustrated.	James Ashworth,	478
Explosion, Wingate Grange Colliery, Illustrated.	James Ashworth,	478
Expresses, Local Trolley,		367
Ferro Concrete Construction,		556
Flash Steam Generator, The, Illustrated.	H. W. Bolsover,	427
Forging Press, The Steam Hammer and,		373
Fowler, George L.: Mechanical Stokers for Locomotives, Illustrated.		75
France, Fulton in, Illustrated.	Henry Harrison Suplee,	405
Fuel Losses in Steam Power Plants,	George H. Barrus,	321
Fulton in France, Illustrated.	Henry Harrison Suplee,	405
Gairns, J. F.: Petrol Tractors,		84
Some Remarkable Locomotives of 1906,		144
The Promotion of Employees,		420
Working Agreements Between Manufacturers,		350
Gas Mantles, Incandescent, Illustrated.	Harold Baron,	201
Generator, The Flash Steam, Illustrated.	H. W. Bolsover,	427
Germany, Naval Developments in,		370
Gibson, A. H.: The Energy Problem of the Universe,		379
Good, T.: The Iron Ore Supplies of Great Britain,		37
Industrial Legislation and Its Cost,		209
Great Britain, The Iron Ore Supplies of,	T. Good,	37
Hart, Joseph H.: Refrigeration as an Auxiliary to the Power Plant,		291
The Problem of Illumination,		123
Hale, R. S.: Municipal Ownership in England,		3, 178, 237
Heavy Passenger Locomotives,		463
Higher Costings,	Arthur Winder,	517
Hodgins, George Sherwood: Wheel Loads and Rail Weights, Illustrated.		487
Horner, Joseph: Some Recent Developments in Machine Tools, Illustrated.		263, 312
Hurd, Archibald S.: The American Fleet from an English Point of View, Illustrated.		467
Illumination, The Problem of,	Dr. Joseph H. Hart,	123
Incandescent Gas Mantles, Illustrated.	Harold Baron,	201
Incandescent Lamps, Recent Progress in Electric,	Lionel Calisch,	354
Industrial America, Illustrated.	J. E. Livermore,	250, 295
Industrial Legislation and Its Cost,	T. Good,	209
Internal Waterways in the United States, Revival of,	George Ethelbert Walsh,	498
Inventors, Civilian,		463
Iredell, F. W.: Biography of Wm. Lawrence Saunders, with portrait,		191
Iron Ore Reserves of the United States, Illustrated.	John Birkinbine,	99
Iron Ore Supplies of Great Britain, The,	T. Good,	37
Isolated Plant, The Central Station and the,	H. S. Knowlton,	359
Job, Robert: Breakages of Steel Rails, Illustrated.		66
Kershaw, John B. C.: The Electrometallurgical Industries in 1907, Illustrated.		26
Kloman, Charles H.: The Growth and Development of the Elevator Industry, Illustrated.		389
Knowlton, H. S.: The Central Station and the Isolated Plant,		359
Kress, H. H.: The Belmont Tunnel in New York, Illustrated.		364
Lamps, Recent Progress in Electric Incandescent,	Lionel Calisch,	354
Large Battleships, Docks for,		368
Lart, F. A.: The Use of Steel in Locomotive Construction,		434
Law of Economical Proportion Applied to Tramway Rolling Stock, The,	William R. Bowker,	140

		PAGE
Legislation and Its Cost, Industrial,	T. Good,	209
Lifting Magnets, Illustrated.	Chas. R. Benjamin,	544
Light Railways,		557
Livermore, J. E.: Industrial America, Illustrated.		250, 295
Local Trolley Expresses,		367
Locomotives, British Tank, Illustrated.	J. R. Thompson,	357
Locomotive Construction, The Use of Steel in,	F. A. Lart,	434
Locomotives, Heavy Passenger,		463
Locomotives, Mechanical Stokers for. Illustrated.	George L. Fowler,	75
Locomotives of 1906, Some Remarkable, Illustrated.	J. F. Gairns,	144
Locomotive Testing Plants,		186
Losses in Steam Power Plants, Fuel,	George H. Barrus,	321
Machine Tools, Some Recent Developments in, Illustrated.	Joseph Horner,	263, 312
Magnets, Lifting, Illustrated.	Chas. R Benjamin,	544
Mantles, Incandescent Gas, Illustrated.	Harold Baron,	195
Manufacture of Steel Rails, The,	James C. Bayles,	195
Manufacturers, Working Agreements Between,	J. F. Gairns,	350
Marine and Naval Engineering,		94
Mechanical Stokers for Locomotives, Illustrated.	George L. Fowler,	75
Mining and Smelting Quicksilver Ore in Kweichow, China, Native Methods of, Illustrated.	Henry Brelich,	127
Monorail, The Brennan,		284
Motor Car, A Swedish Railway,		285
Multiple Turbine Air Compressors,		372
Municipal Ownership in England,	R. S. Hale,	3, 178, 237
Municipal Traffic Congestion,		374
Naval Developments in Germany,		370
Naval Engineering, Marine and,		94
Naval Programme, The British,		189
Naval Wireless Telegraphy,		190
Navigation, William Symington and the Beginning of Steam, Illustrated.	Robert Cochrane,	525
New York City, The Rock Drill and Its Share in the Development of, Illustrated.	Frank Richards,	160
New York, The Belmont Tunnel in, Illustrated.	H. H. Kress,	364
New York, The Engineering Societies Building in, Illustrated.		12
Ore Reserves of the United States, Iron, Illustrated.	John Birkinbine,	99
Passenger Locomotives, Heavy,		463
Petrol Tractors, Illustrated.	J. F. Gairns,	84
Plant, The Central Station and the Isolated,	H. S. Knowlton,	359
Plants, Fuel Losses in Steam Power,		321
Plants, Locomotive Testing,		186
PORTRAITS:		
Jacobus, David Schenck,		2
Saunders, William Lawrence,		98
Bender, Adolph,		195
Chesney, Cummings C.,		290
Fulton, Robert,		378
Barrett, John,		466
Power Plants, Fuel Losses in Steam,	George H. Barrus,	321
Power Plant, Refrigeration as an Auxiliary to the,	Joseph H. Hart,	291
Power Tariffs, Electric,	C. S. Vesey-Brown,	304
Practical Cost Finding,		371
Practice, Efficiency in Steam Boiler, Illustrated.	Percival Cooke,	47, 106

		PAGE
Preservation of Iron and Steel,		556
Problem of Illumination, The,	Dr. Joseph H. Hart	123
Problem of the Universe, The Energy,	A. H. Gibson,	379
Progress in Electric Incandescent Lamps, Recent,	Lionel Calisch,	354
Promotion of Employees,	J. F. Gairns,	420
Proportion, The Law of Economical, as Applied to Tramway Rolling Stock,	William R. Bowker,	140
Quicksilver Ore in Kweichow, China, Native Methods of Mining and Smelting, Illustrated.	Henry Brelich,	127
Rails, Breakages of Steel, Illustrated.	Robert Job,	66
Rails, Steel,		555
Rails, The Manufacture of Steel,	James C. Bayles,	195
Rails, Wear of,		555
Railway Motor Car, A Swedish,		285
Railway Signals,		555
Railway Traction, Steam and Electric,		93
Rail Weights, Wheel Loads and, Illustrated.	George Sherwood Hodgins,	487
Recent Developments in Machine Tools, Illustrated.	Joseph Horner,	263, 312
Recent Progress in Electric Incandescent Lamps,	Lionel Calisch,	354
Refrigeration as an Auxiliary to the Power Plant,	Dr. Joseph H. Hart,	291
Regulation of Steam Engines, The Speed, Illustrated.	Sterling H. Bunnell,	505
Remarkable Locomotives of 1906, Some, Illustrated.	J. F. Gairns,	144
Revival of Internal Waterways in the United States,	George Ethelbert Walsh,	498
Richards, Frank: The Rock Drill and Its Share in the Development of New York City, Illustrated.		160
Rock Drill and Its Share in the Development of New York City, The, Illustrated.	Frank Richards,	160
Rolling Stock, The Law of Economical Proportion as Applied to,	William R. Bowker,	140
Safety Appliances in the Engine Room, Illustrated.	William Wallace Christie,	333
Service, Suburban Trolley,		367
Signals, Railway,		555
Shop Expense, Distribution of,	Arthur Winder,	517
Smoke Problem, The,	David Townsend,	539
Special Tools, Applications of,		464
Some Remarkable Locomotives of 1906, Illustrated.	J. F. Gairns,	144
Some Recent Developments in Machine Tools, Illustrated.	Joseph Horner,	263, 312
Speed Regulation of Steam Engines, The, Illustrated.	Sterling H. Bunnell,	505
Standardization and Conservatism,		461
Steam and Electric Railway Traction,		93
Steamboats, Early,		554
Steam Boiler Practice, Efficiency in, Illustrated.	Percival Cooke,	47, 106
Steam Engines, The Speed Regulation of, Illustrated.	Sterling H. Bunnell,	505
Steam Generator, The Flash, Illustrated.	H. W. Bolsover,	427
Steam Hammer and Forging Press, The,		373
Steam Power Plants, Fuel Losses in,	Geo. H. Barrus,	321
Steam Navigation, William Symington and the Beginning of, Illustrated.	Robert Cochrane,	525
Steel Rails, Breakages of, Illustrated.	Robert Job,	66
Steam Turbine, The, Illustrated.	Charles Proteus Steinmetz,	226
Steel in Locomotive Construction, The Use of,	F. A. Lart,	434
Steel Rails, The Manufacture of,	James C. Bayles,	195

		PAGE
Steinmetz, Charles Proteus: The Steam Turbine, Illustrated.		226
Stock, The Law of Economical Proportion as Applied to Tramway Rolling,	William R. Bowker,	140
Stokers for Locomotives, Mechanical, Illustrated.	George L. Fowler,	75
Suburban Trolley Service,		367
Suplee, Henry Harrison: Fulton in France, Illustrated.		405
Supplies of Great Britain, The Iron Ore,	T. Good,	37
Swedish Railway Motor Car, A,		285
Symington and the Beginning of Steam Navigation, William, Illustrated.	Robert Cochrane,	525
Tank Locomotives, British, Illustrated.	J. R. Thompson,	357
Tariffs, Electric Power, Illustrated.	C. S. Vesey-Brown,	304
Technical Training,		461
Telegraphy, Naval Wireless,		190
Telephone Exchanges, Aerial Cable Construction for, Illustrated.	C. W. Burkett,	216
Terminal Transport Facilities,		375
Testing Plants, Locomotive,		186
Thompson, J. R.: British Tank Locomotives, Illustrated.		357
Tools, Applications of Special,		464
Tools, Some Recent Developments in Machine, Illustrated.	Joseph Horner,	263, 312
Torpedoes and Submarine Boats,		557
Townsend, David: The Smoke Problem,		539
Traction, Steam and Electric Railway,		93
Tractors, Petrol, Illustrated.	J. F. Gairns,	84
Traffic Congestion, Municipal,		374
Training, Technical,		461
Transport Facilities, Terminal,		375
Tramway Rolling Stock, The Law of Economical Proportion as Applied to,	William R. Bowker,	140
Trial Cruise of the Dreadnought,		187
Trolley Expresses, Local,		367
Trolley Service, Suburban,		367
Tunnel in New York, The Belmont, Illustrated.	H. H. Kress,	364
Turbine Air Compressors, Multiple,		372
Turbine, The Steam, Illustrated.	Charles Proteus Steinmetz,	226
United States, Revival of Internal Waterways in the,	George Ethelbert Walsh,	498
Universe, The Energy Problem of the,	A. H. Gibson,	379
Use of Steel in Locomotive Construction, The,	F. A. Lart,	434
Utilization of By-Products,		372
Vesey-Brown, C. S.: Electric Power Tariffs,		304
Walsh, George Ethelbert: Revival of Internal Waterways in the United States,		498
Waterways in the United States, Revival of Internal,	George Ethelbert Walsh,	498
Wear of Rails,		555
Wheel Loads and Rail Weights, Illustrated.	George Sherwood Hodgins,	487
Welding, Autogeneous, Illustrated.	F. C. Cutler,	441
William Symington and the Beginning of Steam Navigation, Illustrated.	Robert Cochrane,	525
Winder, Arthur: Higher Costings,		517
The Distribution of Shop Expense,		517
Wingate Grange Colliery Explosion, Illustrated.	James Ashworth,	478
Wireless Telegraphy, Naval,		190
Working Agreements Between Manufacturers,	J. F. Gairns,	350

DAVID SCHENCK JACOBUS

ADVISORY ENGINEER, THE BABCOCK & WILCOX CO.

SEE PAGE 95

INDEXED

CASSIER'S MAGAZINE

VOL. XXXII MAY, 1907 No. 1

U. S. PATENT OFFICE LIBRARY MAY 8 1907

MUNICIPAL OWNERSHIP IN ENGLAND

THE BRITISH PROBLEM CONSIDERED FROM AN AMERICAN VIEWPOINT

By R. S. Hale

The following article was prepared in the early part of 1906, after a careful study of conditions existing in England at that time, and although some changes have since taken place, these are, for the most part, local and unimportant, so that the paper may be considered as representing very fairly the present status of the municipal ownership problem as it appears to a conservative American observer. Sometimes such a view is of more real value than a study by one whose closer relations to the home conditions render it impracticable for him to divest himself wholly from the influence of his surroundings. Mr. Hale, we believe, presents the problem in a manner altogether free from any material bias, and therefore of much value to engineers and economists on both sides of the ocean. The present installment treats of the subject in its general bearings, and also discusses the operation of gas and water works, and it will be followed by a critical examination of the questions involved in the operation of tramways, electric lighting systems, and telephones.—THE EDITOR.

THE following memoranda and discussion do not pretend to be a complete statement of the municipal ownership question in England. That would be impossible, since municipal ownership is merely a branch of the whole question of society and government, of socialism and anarchy. The history of municipal trading in England, however, has followed certain broad general lines which throw clear light on some of the principles involved. It is not that every instance of municipal trading in England has given the same result, since the individual and personal factor enters even with municipalities, but so far as it goes, English experience is clear.

If I have spent more time in discussing principles than in stating facts, it is because the various publications referred to are so complete that very little is left except to draw conclusions.

First of all, what is meant by municipal ownership or municipal trading?

Nothing is more dangerous to clear thinking than to start with a definition. Therefore, instead of defining municipal ownership we may take as a basis a very valuable Parliamentary report of December 16, 1902, giving a "Return of the Reproductive Undertakings of Municipal Boroughs."

The list is as follows:—

1. Water, gas, tramways, electric lighting, markets, baths, burial grounds, working-class dwellings, piers, quays, harbours.

This is the main list. In addition, returns were made of the following:—

2. Toll bridges, canals, cold stores, conditioning house, crematories, race courses (for horse racing), ferries, parks, theatres, telephones, abattoirs, bonding warehouses, hospitals, lava-

 Copyright, 1907, by The Cassier's Magazine Co.

tories, asylums, sewage-farms, sterilized milk.

3. Besides these there are cities in England carrying on hotels, lodging houses, hydraulic power supply, museums, golf courses, banking rooms and savings banks, and many other businesses.

Still further, many allied trades are carried on in connection with the above. For instance, in connection with gas supply, the manufacture of coke, tar, etc., is carried on, and also the sale of gas supplies and fittings. In connection with the destruction with refuse, paving stones and bricks are manufactured. In connection with the supply of electricity, electric fittings are sold, and, in some cases, manufactured. In connection with the removal of sewage, soap is, in at least one case, manufactured.

Now, in considering the above lists, it is clear that many are not what is generally referred to as municipal trading, though it is often hard to define where the line should be drawn. Parks and museums, for instance, are regarded as proper outlets for municipal activity, even if occasionally a revenue be drawn from them, and likewise schools, hospitals and asylums are not regarded as trading ventures, even if in a hospital the well-to-do man who wants a private room is charged a fee, or if one town carries on a high school and gives to neighbouring smaller towns that cannot support a separate high school, the use of its facilities in return for cash.

When the property of the town is taxed in order to provide streets or parks or museums free of charge to the population of the town, or to part of the population, that is not municipal trading. It is municipal socialism pure and simple, or rather it is the extent to which the cities have adopted the principles of socialism. When the property of the town is taxed in order that some of the population of the town may be supplied with milk, or lodging houses, or education, not perhaps entirely free of charge, but at less than cost, that again is socialism.

Now, I do not mean to discuss socialism. It has some good points. To-day we have adopted socialism, so far as streets, parks, police, education and certain other departments of modern life are concerned. On the other hand, no one, except avowed socialists, would seriously consider a proposal that property should be taxed, in order to provide cabs as freely as the streets are now open to the public or to provide free food in the way that free education is now provided.

We may, therefore, exclude from our list of municipal trading such items as baths and cemeteries, quays and harbours, working-class dwellings, hospitals and asylums, and, in fact, all undertakings where it is the intention to tax property in order to carry on the service for the benefit of the users, at less than its cost. These items come under substantially the same head as parks and schools. It is true that some of these give an income to the municipality, an income that, in rare cases, may even be above the cost, but if an operation is intended as a charity, it can hardly be included in municipal trading.

There are certain features connected with charities, with asylums, with schools and with baths, and with similar operations that are often discussed under the head of municipal trading, but that are quite distinct from the discussion as to whether the municipality shall trade. These features are in brief, the questions comprised in the direct employment of labour as against contract or pay by the day as against payment by the piece.

For instance, a street is to be paved. Will it be done most cheaply if the city buys a contractor's outfit, buys its material and then employs a foreman and gang of men by the day, or if it advertises for bids under specifications and lets the whole work by contract? The problem of lighting the street is exactly the same as

paving it, and is purely a question of direct employment or contract.

This is a question that concerns any private company just as much as it does a city. If an electric company wants a main laid in the street, will it get it done cheapest by letting the contract as a whole, or by buying the copper and the rubber and making the cable, then hiring a foreman and labourers and laying it?

Now, the first of these two questions, viz., to what extent property shall be taxed to provide the whole population or a part of it with services at less than cost, is a question of socialism, not of trading, and, the second, the question of direct employment or contract is likewise not a question of trading, or if it is preferred to call it a trading question, it is a distinct branch of the subject.

We may, therefore, limit our discussion of the long list given above to the cases where a municipality carries on some business, not as a charity, at less than cost, but at a profit.

Now, it is obvious that there can be no continuous profit unless there is a monopoly. One reason, for instance, why no municipality has ever made a profit on milk supply, or food supply, or a theatre, is that the moment it makes a profit someone else steps in and offers the service at a shade lower price, and then the municipality must go out of business or gradually see its profit disappear.

It is true, of course, that occasionally a municipality will, by reason of the civic honor, get some citizen to serve it for less wages or salary than he could make in private trade, and can make a profit through his skill. It is obvious, however, that this cannot exist for all the city trading, except when the number of municipal workers is small, since the moment more than a moderate per cent. of the workers serve the State, there is no particular glory in being one of them as compared with private employ.

The question of municipal trading, therefore, as distinct from the question of charity or socialism or anarchy, and as distinct from the question of day work versus piece work, is merely a question of monopolies. If anyone quarrels with my wording, the dispute is not worth while, and I am perfectly willing to admit that socialism and municipal trading are much the same thing. I only wish to point out that we have quite distinct classes:—

1. So-called charities, or work done at a loss. Here, the question of whether we shall do them, I call socialism or anarchy, and the question of how they shall be done I call the question of day work versus piece work.

If the work is done at a loss, it makes no difference whether it is a monopoly or not.

2. Work done at a profit. This can exist permanently only in the case of monopolies, and it is this class of work that I propose to consider under the head of municipal trading.

Taking the lists of trades already given, we find water, gas, tramways, electric lighting and telephones as the trades that are usually considered as the municipal monopolies. So far as the rest of the list is concerned, no one objects on trading grounds to a municipality building a hospital or a park or a museum, even when it is found convenient to make a small charge for their use. Few object to a city's charging a small toll on a bridge or a municipal ferry. Of course, a city may be extravagant like New Bedford and Fair Haven, with their bridge, or like the English city that recently imported Italian workers to put a tesselated mosaic floor in a pauper lunatic asylum, but the objection is against the extravagance, not against the bridge or the asylum.

The same principle applies to municipal baths and to municipal cemeteries. The objection to them is on socialistic rather than on trading grounds. There are, of course, cer-

tain dangers besides the socialistic ones, even in these branches of municipal activity. For instance, if the city provides free cemeteries it would certainly discourage the development of crematories, in spite of their great public advantage. Free municipal bathing places would discourage private builders from putting baths in private houses. Free ferries across a river would prevent private capital from building a toll bridge, and the present free supply of roads has undoubtedly checked the building of turnpikes by private capital for a profit.

History indicates, however, that such dangers are more imaginary than real. If crematories, for instance, are better than cemeteries, the cities ought to take them up and supply free cremation instead of free cemeteries. Education certainly has not suffered because the State supplies it at less than cost; in fact, there have in the past been practically no trades that have been seriously checked, or rather checked to the public disadvantage because they have at times been a charity.

In the case of markets or working-house dwellings, in which there is no monopoly, it is obvious that no profit except by accident can be made, and again the question is one as to whether a particular expenditure of a charitable nature or rather for a charitable purpose, is a wise one.

The only way to learn the future is from the past, and in municipal trading or any feature of government the causes take so long to produce their effects that the problem is a difficult one.

We will now take up very briefly, the history of these municipal activities in England that have been carried on for a profit.

Roads.—From the earliest times, roads have been a branch of municipal activity, especially as regards the streets inside of towns. Nevertheless municipalities took up the highways between towns in a very sluggard fashion, while private capital did step in, build turnpikes and toll bridges. About 1850, however, municipal activity became greater and the turnpikes were taken over and became public property. Some of them may have been profitable, but I rather gather the majority were not, and that most were taken over on their earning power alone and at less than cost. To-day practically no turnpikes or toll bridges are left.

Water.—Water was the first great public service of the nature of trading. In England the first water supplies, other than wells, were about 1400 to 1500. These supplies were almost invariably started by private enterprise, only twelve towns in England being said to have built their own waterworks (See Municipal Year Book, 1905, p. 367). The tendency for the cities to take up the work has been very marked of late years, and to-day it is by law the duty of the rural district councils to see that every house is properly supplied with water, i. e., if private enterprise does not, the municipalities not only may, but must see that it is supplied (See Municipal Year Book, 1905, p. 367). The private waterworks were almost always established by private Act of Parliament giving perpetual franchise. The charges were almost invariably based on the assessed valuation of the property to which the water was supplied, and in some cases as of the New River Water Company, in London, this gave tremendous earning power as the valuation of the property went up. Companies established after 1847 were, however, limited to 10 per cent. dividends on their paid-up capital by the Act of 1847.

The tendency has been for some years for the private supply of water to pass into municipal hands, the purchase being almost invariably as a going concern, which, in many cases, though by no means all, has given good profits to the stockholders.

The result of these laws, so far as development is concerned, has been good, i. e., probably every town is

now supplied with water. Public water supply has now become to such extent a public necessity, and not a luxury as it was 100 years ago, that in new and growing districts it is as much a municipal duty to extend the water mains as it is to extend the streets.

The cost for water supply varies so much according to locality that no comparison is practicable between private and public ownership. Undoubtedly rates have, in many cases, been reduced after purchase by the municipalities, but in some cases, as, for instance, at the recent municipalization of London water, rates have been increased, and in many cases private companies have reduced their rates. To-day most of the private water supplies that are left are in the smaller towns where the cost of water supply is higher, and where the question of whether waterworks will pay a direct profit, as distinct from the gain to the general health, is a doubtful question.

Gas.—Gas supply started in 1812 and the first municipal works were at Keighly about 1824, and the first important municipal works were at Manchester in 1844. In 1850 less than twelve municipalities were supplying gas, all the others who did not permit private enterprise going without.

The history of gas supply in London is well told in Rostron's "Powers of Charge of the Metropolitan Gas Companies, 1900."

In brief, the story is as follows:—The ownership being entirely private:

1811 to 1840 or 1850.—Free competition among several companies. Result, poor service, moderate price, poor dividends.

1850 to 1870.—Regulated monopoly by means of a maximum dividend and maximum price. Result, much better service and much better dividends, prices about the same.

1870 to date.—Sliding scale. Result, still better service and dividends, and much lower prices.

As regards municipal ownership of gas outside of London, this, to any great extent, did not start until about 1860-1870. With a very few exceptions the cities bought out the companies as going concerns, paying in many cases high premiums above the nominal value of the shares.

For comparing municipal ownership with private, no final test can, of course, be applied, but statistics on the gas industry, while not perfect, yet in England are so complete that many interesting tests can be applied. Returns giving various statistics of all Parliamentary gas undertakings, both municipal and private, are published annually. In the Municipal Year Book, 1905, p. 379, those for 1901-02 and 1902-03 are summarized.

The average price per 1000 feet under municipal ownership was 2s. 8d., and private ownership 2s. 11d., and there have been several similar comparisons made giving substantially the same result.

It has been stated that the difference is in part at least due to the smaller average size of the privately owned plants involving higher cost, and that in plants of similar size and under similar conditions, the difference is in favor of the companies.

This is not borne out by the statistics, since the private and municipal statutory plants, for which statistics are available, seem to average about the same size, due to the inclusion of the large London companies.

At first sight it is borne out by Field's analyses, which give the following results:—

	Average Price per 1,000 feet of Typical Provincial Municipalities.	Average Price per 1,000 feet of Typical Provincial Companies.
	d.	*d.*
1900	27.0	25.8
1901	28.9	26.9
1902	29.9	26.1
1903	29.4	25.3
1904	28.2	24.3

This, however, is not a fair comparison since the candle-power averages distinctly higher in the municipalities, and allowing for this it seems clear that the municipal price is very

slightly lower under similar circumstances, though only very slightly.

Inspection of the Gas World directory, 1905, also shows clearly that in towns of the same size the price is about the same, whether under private ownership or municipal ownership, but certainly no higher under municipal ownership than with private companies.

In addition, in the case of municipal ownership there has been, in some cases, a decided profit to the city finances. This is best shown from Field's Analyses, showing a net profit to nine large cities of some 2 per cent. to 3 per cent. on capital invested over and above interest on borrowed money and sinking fund.

In the case of the smaller municipal works the profit has been nowhere near as large as this, and in a few cases there are losses. As a general average, however, there is a small profit. In regard to the accuracy of these accounts, or rather of municipal accounts generally, two questions are often raised. First, as to depreciation, and, second, as to whether all the charges have been put in.

As to depreciation, the depreciation for any given year is always a matter of judgment. If, however, depreciation is not properly charged up, it, before long, begins to show in high investment or operating charges. Now, from Field's Analyses, and from the Parliamentary returns, it is clear that the investment of the companies per 1000 feet sold is fully as high, and, in fact, higher, than of the municipalities, and while in general it is gradually going down, yet it is going down at least as fast for the municipalities as for the companies. Unless we are prepared to claim that the companies' accounts are all wrong, and that investors who are willing to buy English gas stocks at present prices are foolish, we must admit that the municipalities (which have kept their capital proportionately lower than the companies) have in sinking funds and ordinary maintenance, taken at least enough account of depreciation. There are exceptions no doubt. Coventry has just had to mark off £40,000 or so for abandoned works, although they have been claiming a net profit for several years.

This test, however, takes the municipal sinking funds as equivalent to depreciation. If the results be figured as though the sinking fund were a profit, the figures are not quite as good, but even then it appears probable that enough depreciation has been allowed.

In regard to the question of whether all the management expenses, etc., are properly charged into the gas undertakings of municipally-owned gas works, no one, for instance, can tell, but what the chief engineer's salary and some of his office expenses may not have been charged to some other account. There are, however, two tests, which, while not conclusive, are of value.

First, the gas expenses are coal, works cost, distribution cost and management and taxes. The coal and works cost of a municipal ownership ought to be fairly accurate. It is hard for municipally-owned works to get coal or labour for manufacturing from any other city department. In the case of distribution expenses, however, it is at least possible that there may be some improper shifting of expenses, while in the case of management expenses, this is more likely still.

Hence, comparison of these expenses will tend to show if there has been any improper accounting.

The actual results in pence per 1000 feet are as follows, taking Field's Analyses for 1886, 1896, 1900 and 1904. It must be remembered that these are not necessarily of the same undertakings in the different years, due to consolidation, transfers, etc. (See table opposite.)

The differences here are so slight that it seems clear that with the possible exception of management the accounts are at least approximately correct. Even in the case of manage-

	Net Coal.		Other Manufacturing Costs.		Distributing.		Management.		Rates and Taxes.	
	M.	P.	M.	P.	M.	P.	M.	P.	M.	P.
1886	6.74	8.03	7.28	7.77	1.65	1.40	.78	1.48	1.25	1.21
1896.....	7.44	6.85	8.04	8.41	2.12	2.12	.76	1.36	1.47	1.35
1900.....	6.87	6.28	7.88	8.16	2.44	2.33	.69	1.12	1.43	1.09
1904.....	4.95	3.96	8.33	7.36	2.93	3.26	.72	1.21	1.93	1.20

M, stands for municipal; P, for company ownership.

ment it must be remembered that there are certain genuine savings made possible by municipal ownership, since municipal ownership may be regarded as a big consolidation of various departments and should give savings of the same nature as when, for instance, the gas, water and electric supplies are consolidated in the hands of a single company.

So long, too, as municipal trading is kept small, public spirited citizens are willing to give their time on committees, for which, in the case of companies, they would expect directors' fees or their equivalent. It must be remembered, of course, that when (or rather if), municipal ownership, or socialism becomes general, so that all of us are employees of ourselves, this feature will disappear.

In a later portion of this report I shall investigate the question of whether any of the difference in management costs does not reappear in other municipal accounts, and I may say here, that some of the savings claimed by municipal trading do apparently reappear in other accounts, but even allowing for this the municipalities are doing as well for the consumer and taxpayer as the private plants.

The fact that municipalities that own gas works are charging themselves more rates and taxes on their own gas works than neighbouring cities are on privately-owned works is a strong endorsement of the general accuracy of the accounts in spite of the slight difference on management.

We may, therefore, conclude that there is no very serious error in the gas accounts, especially if sinking fund is regarded as depreciation.

We may, therefore, conclude that gas consumers are at least as well off under municipal ownership as under private ownership under English conditions, and probably better off, and that municipal ownership of gas works has resulted in a slight profit to the taxpayer, amounting in a few towns to 2 per cent. to 3 per cent. on the money he has risked, besides the money paid, in other towns to less. This profit may not in all cases be quite so great as it appears to be, and in a few cases in fact, is a loss; but nevertheless for the average municipal gas plant in England it does not exist.

While both the gas consumer and the rate payer have been better off from municipal ownership, there are two additional features that are very important.

The first is a hypothetical one, nevertheless signs of it have appeared. Suppose, for instance, that electricity or something else should be put in such form that it could be carted around and left at houses, but so cheap and convenient that it would replace gas. In this case the ratepayers of towns owning gas works would lose all their investment, while the town that trusted to private enterprise would be free and clear of debt. This has not yet happened to any municipal undertaking, but the ruins of the iron works on the Atlantic Coast of the United States show that it is a possibility.

Where this feature does actually affect the public interest, is that in some cases a municipality owning the gas works actually discourages or even forbids the establishment of an electric plant for fear that it may cause a loss on the gas undertaking owned by the taxpayers in general, or if owning tramways, discourages omnibus companies. This feature has operated very often in England, in-

stances appearing almost every week and is part of the reason why England is so far behind in electrical matters, but such action is so unfair and so much to the real disadvantage of the community that it is seldom effective for any length of time. It discourages and delays improvements, but does not prevent them. Imagine, however, how long we should have had to wait for electricity if no one had been allowed to build electric plants except the people who owned gas plants.

The other feature we have not considered, is the case of the citizen who does not consume gas at present, but who would save money and increase his private business if he could get gas instead of oil.

In the case of water, water is now considered so much a necessity that a municipality is practically obliged to provide it if a company does not.

In the case of gas, however, we have not got to that point. In England there are hundreds of private gas plants in small places supplying less than 500 consumers, and of these only about 5 per cent. are by municipal enterprise, the balance being due to private enterprise.

The municipalities have equal facilities for establishing these plants that private enterprise has, and even if it be true that when a municipality undertakes the work of gas supply, it does it well, so far as the present consumers are concerned, yet the list of these plants shows that for the public to trust solely to the municipality would result in a few people getting a cheaper supply of gas, but that many towns and a large portion of the public would get no supply at all.

The meaning of this in dollars and cents is not always clear, because it is seldom that a customer paying $1 per M. for gas will, even to himself admit his willingness to pay $2, although it is not many years since all Boston was paying $2, and that at a time when $2 was a greater proportion of a citizen's income that it is to-day.

Admitting that under municipal ownership the average price of gas would be lower, the statistics indicate that far fewer customers would be using it. The others would be using oil or be in the dark. They are now getting gas at, say, $1, but only a few of them would give it up entirely if the price were raised to $2. The difference between $2 and the much lower price they now pay, represents the loss they would sustain if they had to do without gas, as would have been the case if they had trusted solely to municipal ownership. It is like saying to a man in the country, "We know you are willing to pay $2 rather than not have gas. We know that a company is ready to take the risk of supplying you at $1, but that would be at a good fat profit for the company, which is against public policy. We therefore ask you to wait twenty years and we will then give you municipal gas for 90 cents." Or, a better comparison still is forbidding a street railway to carry him for 10 cents, because that would give too big a profit, and bidding him wait until the municipality gets around to carrying him for 5 cents.

This feature of municipal ownership is well brought out by the English official figures of Aug. 10, 1894, on gas statistics. In 1882 private plants supplied 1,055,009 consumers, and municipal plants 916,962. In 1903 the figures were 2,385,348 and 1,945,777, an increase for private ownership of 1,330,239, or 125 per cent. and municipal ownership of 1,028,815, or 112 per cent.

During this time, however, fifty-two works have been acquired by municipalities, and while no immediate statistics are available, it is well known that the great majority of these have been taken over from companies and very few started direct by the municipalities. It is also well known that practically no municipalities have disposed of their works to companies. It is, therefore, safe to say that several 100,000 of the increase in municipal customers are due

merely to transfer of ownership, and that these customers owe their ability to get gas to private, and not to municipal enterprises. According to this, if, in 1882, all the plants had been put under municipal ownership, the total number of consumers would have been to-day something like 3,000,000 instead of 4,300,000, and while the 3,000,000 might have been getting their gas a few cents cheaper, the other 1,300,000 would have been in the dark.

These figures are from the so-called statutory companies or large companies.

The Municipal Year Book, 1905, p. 379, shows that while of these, roughly one-third are municipal, that in addition there are about 400 more so-called non-statutory companies, mostly small undertakings, of which, only twenty-six are municipal. To-day, of course, there is not the slightest risk in building a gas works for a large town, but there is a great risk in the case of a small one. This brings out, of course, even more the way in which private ownership does the work, though at a slightly higher price, while municipal ownership does, what it does do, well, but if there is the slightest risk leaves much undone, and leaves a large proportion of the public without service.

In a succeeding paper the operation of electrical undertakings, both under municipal and private management, will be considered.

(To be continued.)

THE ENGINEERING SOCIETIES BUILDING IN NEW YORK

WITH the dedication of the Engineering Societies Building in New York there has been carried to a completion the most ambitious structure yet planned as a home for organizations connected with the applied science of engineering. Various descriptions of this important structure and its purposes have been already made public, and it is not here intended to give a detailed account of the building, but rather to compare its arrangements and facilities with those of some of the buildings devoted to similar purposes in other parts of the world.

As has already been widely published, the Engineering Societies Building owes its existence to the generosity of Mr. Andrew Carnegie, who, early in 1903, offered the sum of $1,000,000 for the erection of a building to be the home of the several national engineering societies, this amount subsequently being increased to $1,500,000 as the scope of the plans indicated desirable, this including not only a general society building, but also a house for the social organization, the Engineers' Club. The result of this offer is the magnificent building situated on Thirty-ninth street, near Fifth avenue, close by the new building of the New York Public Library, in proximity to the leading clubs, and not far from the principal residence section of the metropolis.

The general view of the building shows the manner in which the exterior indicates the interior arrangement. The lower portion is devoted to the main and auxiliary auditoriums, the middle section to offices and business rooms, and the upper part to the library. These divisions correspond closely to the arrangement of the exterior, the columns, with their entablature, marking the level of the main auditorium and the ornate section above showing the location of the smaller meeting rooms, while the vertical reach of the main pilasters covers the office portion, leaving the library floors at the top to be indicated by the resumption of decoration, crowned by cornice and parapet.

From the sidewalk up to the auditorium floor the material is limestone, followed by gray mottled brick and terra-cotta above, the whole having a cream tint, very agreeable to the eye. The foundations were carried down to rock, found at depths of 27 to 67 feet below the surface, the structure being supported on forty piers of concrete. The building contains 2650 tons of structural steel, and, as a large portion of the load of the upper floors had to be car-

THE ENGINEERING SOCIETIES BUILDING IN NEW YORK. FACADE FROM THE DRAWING OF THE ARCHITECTS, MESSRS. HALE & ROGERS, HENRY G. MORSE, ASSOCIATED

THE ENGINEERING SOCIETIES BUILDING IN NEW YORK

INSTITUTION OF CIVIL ENGINEERS, GREAT GEORGE STREET, LONDON

THE INSTITUTION OF MECHANICAL ENGINEERS, STOREY'S GATE, ST. JAMES'S PARK, LONDON

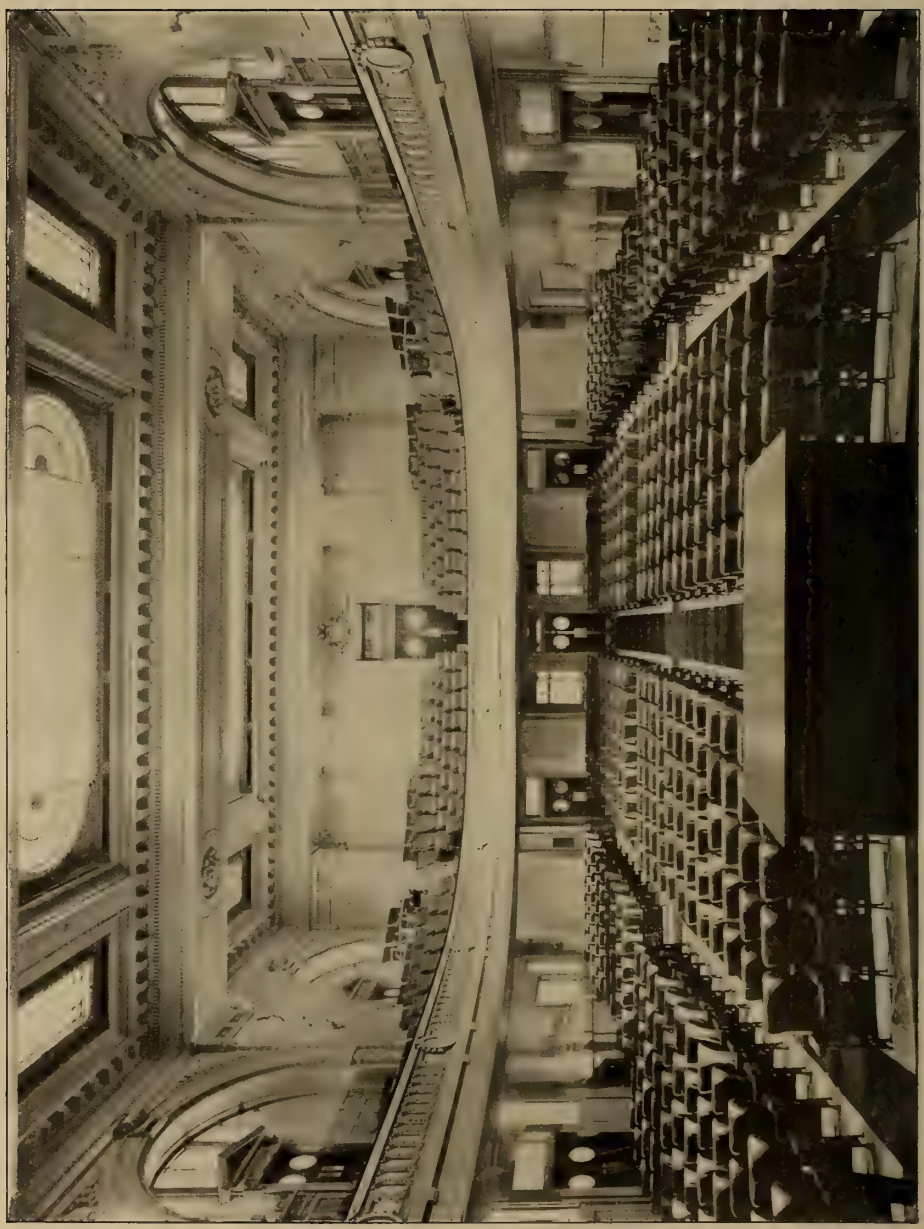
ried on the girders spanning the main auditorium, these were made amply strong, weighing 48 tons each, while on the sixth floor the steel lattice truss weighs 64 tons.

From the handsome lobby on the ground floor the grand stairway leads to the main auditorium on the first floor. Between these levels there is a mezzanine floor, giving a broad landing communicating with the cloak rooms, these latter being formed in the space beneath the slope of the auditorium floor, thus utilizing room otherwise useless, and providing ample accommodation and free access for the care of wearing apparel without blocking the main passages and

SOCIETE DES INGENIEURS CIVILS DE FRANCE, RUE BLANCHE, PARIS

flow of movement. This feature is one generally neglected in similar buildings, as witnessed by the struggle and confusion so general after the dismissal of a large audience.

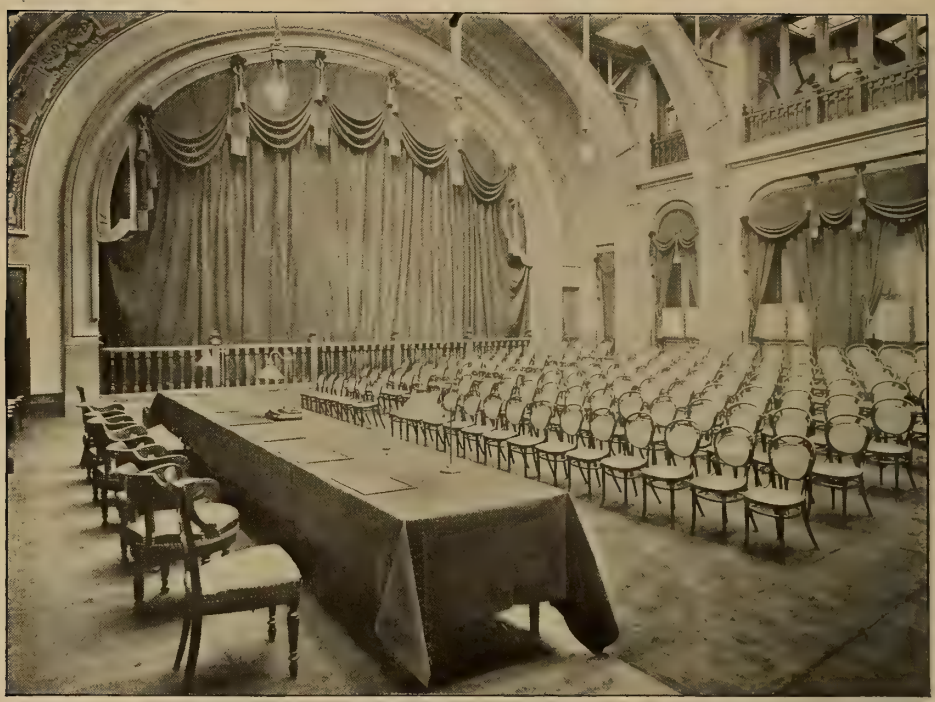
The main auditorium has been designed to meet the special requirements of the building, and in the illustration it is shown as viewed from the stage. The room has a seating capacity for 1000 persons, and has been arranged to meet the requirements both of a lecture hall and a chamber for debate, especial attention having been given to the attainment of good acoustic qualities from all parts of the floor, as well as from the stage. Wide corridors



MAIN AUDITORIUM IN THE ENGINEERING SOCIETIES BUILDING

AUDITORIUM, INSTITUTION OF CIVIL ENGINEERS

AUDITORIUM, INSTITUTION OF MECHANICAL ENGINEERS



AUDITORIUM, SOCIETE DES INGENIEURS CIVILS

surround the hall, with numerous points of entrance, it being the intention to provide here suitable lounging space for those who may prefer to withdraw from the discussion for a time, and yet be within convenient reach of the room. A passageway back of the stage communicates with the retiring rooms and connects the side corridors, permitting ready and private access to either side of the building, as well as providing a convenient place for the switchboard controlling the electric lighting of the room.

On the two floors above the main auditorium there are provided seven lecture rooms of various sizes, these, with the main hall, seating audiences of from 100 up to 1000 persons, the rooms on the fifth floor being so arranged as to be thrown together for receptions and similar gatherings, provision being made for the serving of refreshments.

On the upper floors are the suites of offices, the three founder societies, the American Institute of Mining Engineers, the American Institute of Electrical Engineers and the American Society of Mechanical Engineers, occupying the ninth, tenth and eleventh floors, respectively, while the seventh and eighth floors have been arranged to provide offices for such scientific organizations as may desire to become associated in the occupation. The building is thus planned to facilitate in every respect the desire of its founder, Mr. Andrew Carnegie, and become the home and centre of engineering in the United States.

The library, including the collections of the three founder societies, is to be housed on the top floors of the building, the main reading room, containing also the reference works and sets of technical periodicals, being on the uppermost floor, while the whole of the floor below is devoted to book stacks, furnishing ample room for future growth. The illustration of the reading room shows

LIBRARY OF THE INSTITUTION OF CIVIL ENGINEERS

the effectiveness of the lighting, and gives an excellent idea of the ample provision which has been made for this important department of the work of the associated institutions.

The great advantages obtained by joint occupancy of the same house by several societies appears in many ways. Thus, general conventions are held but two or three times a year, and there is no reason why each institution should maintain a hall large enough for a large gathering solely for its own use. The dates for such conventions can readily be so arranged as to permit each organization to have the full use of the main auditorium without interference, while for minor gatherings the smaller rooms meet every requirement. When, as will doubtless be the case, the house serves as the meeting place of scientific congresses and similar gatherings, the general assemblage may be held in the large hall, while the various sections will have the seven smaller rooms at their disposal, in accordance with their relative numbers.

The libraries will be immeasurably strengthened by their union into one working library, covering all the various branches of engineering, each receiving far more than it gives by association with the others. By appropriating an entire floor for the business and executive offices of each of the three founder societies the integrity of each is fully maintained, and meetings of committees, governing boards, and conferences are held with the same independence and privacy as could possibly be secured in separate buildings.

It will be interesting at the present time to compare some of the arrangements of the building of the United Engineering Societies with those of other engineering organizations, and for this purpose the illustrations are so arranged as to show the meeting halls of some of the European insti-

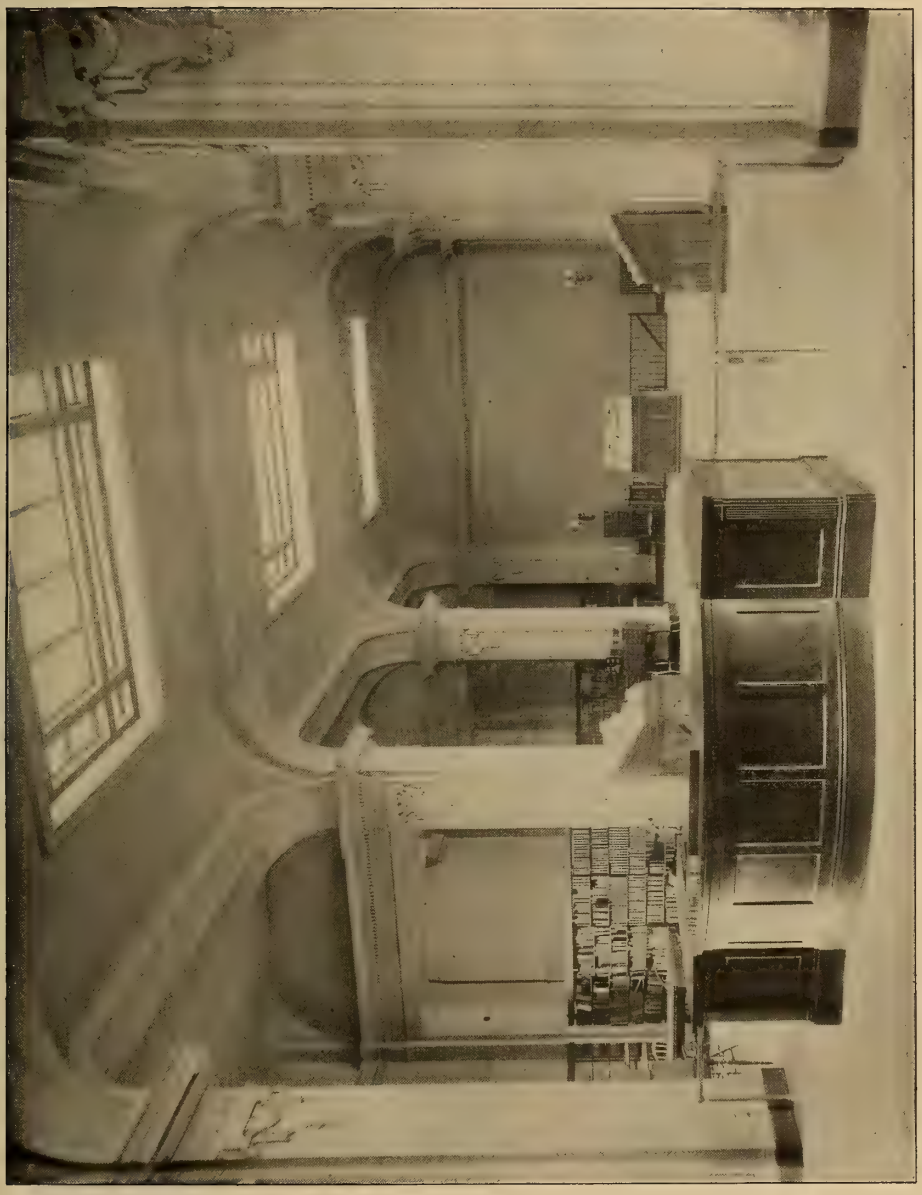
LIBRARY OF THE INSTITUTION OF MECHANICAL ENGINEERS

tutions. So far as external appearances go, comparisons are difficult, since the building in New York, with its fourteen stories and 218 feet of altitude, differs wholly in style and proportions from the others. The frontage of 115 feet prevents the new building from appearing disproportionately high, the whole aspect being of a monumental character, and the broad treatment of the façade is in acordance with the dimensions.

Taking now the building of the Institution of Civil Engineers, in Great George street, London, while lacking the size of the building in New York, it presents a dignified and even stately appearance, the smaller scale permitting rather greater detail in the decoration, even to the extent of the addition of portrait busts of eminent members of the profession, including Telford, Brindley, Watt, Stephenson, Brunel, and Smeaton.

The interior of the building shows a marked contrast with the engineering building in New York, especially in the auditorium. The London interior resembles rather the lecture hall of some great university, or a medical amphitheatre, a working room where students gather to absorb the experience of their predecessors, and a similar impression is gained from the view of the corresponding room of the Institution of Mechanical Engineers, the near neighbour of the older institution. The auditorium in New York is more like that of the other great society across the Channel, the Société des Ingénieurs Civils de France, although this, too, has its own peculiar characteristics.

Comparing the libraries, the brilliancy of the lighting of the room at the top of the tall New York building shows in marked superiority to the sombre dignity of the library in Great George street, even though the rays of the sun extend across the



READING-ROOM FLOOR OF THE ENGINEERING SOCIETIES BUILDING
This room is at the top of the building, permitting the overhead illumination The stack-room occupies the entire floor below

latter room. The library of the Institution of Mechanical Engineers is well lighted and conveniently arranged, and both rooms show by their fuller cases and other contents that the advantages of time have been on their side, but it is to be hoped that the bareness of the American library will soon be relieved, as the accumulations of years find their resting place there. It is true that

MEMORIAL TO GIFFARD. SOCIETE DES INGENIEURS CIVILS DE FRANCE

in the American hall there will soon be placed a bronze portrait bust of the founder, while other portraits and souvenirs are already planned. In this connection attention may be called to the beautiful memorial to M. Henri Giffard, forming one of the striking features of the hall of the Société des Ingénieurs Civils de France. The façade of the house of the French society also forms an agreeable contrast to those of the London bulidings, the effect being remarkably good, in view of the fact that the limited width of the Rue Blanche renders it difficult to judge of its proportions.

The building of the Engineering Societies in New York is remarkable for the extent to which modern engineering appliances are included in its equipment. Thus, it is provided with electrical supply by means of two separate feeders from the New York Edison Company, giving current for lighting and for power in such a manner that interruption is practically impossible. The illumination of the main auditorium is designed upon a most effective plan, there being sufficient space between the ceiling and the floor above to permit the introduction of the electric lamps so that the light fills the room through the glass septum of the panels in the ceiling. All glare from visible lamps is thus avoided, and the degree of illumination is accurately controlled from the switchboard behind the stage. When the projecting lantern is used the room can be darkened at will, the general illumination being restored gradually, to avoid any unpleasant sensations upon the eyes. In the smaller rooms the cove system is employed, with additional outlets for fixture lighting where necessary. The two large passenger elevators are operated by electric power, and represent the latest practice in this department of work, the speed being 325 feet per minute with 2500 pounds load. In the electrical equipment may also be mentioned the installation in the building of a general telephone exchange, with a capacity of fifteen central-office lines and sixty extension telephones, giving local, suburban and long-distance service, the present arrangement covering 12,000 messages per year.

The heating and ventilating equipment of the building is thorough and complete, pure, fresh air being supplied by blowers representing a supply of 100,000 cubic feet per minute, the air being filtered, warmed, and tempered. The heating is effected by low-pressure direct radiation, but

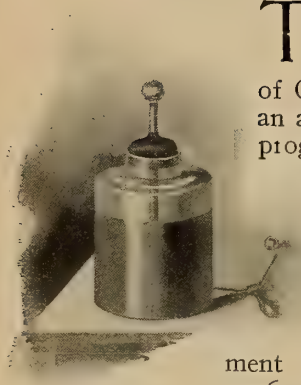
the steam boilers and their piping system are planned for high-pressure service should it hereafter be decided to install an isolated electric plant.

Prior to undertaking the work in connection with the Engineering Societies Building, it was found necessary to organize a holding corporation to administer the endowment and property for the founder societies jointly and in common, and the novel conditions attending the acceptance and utilization of the gift raised many legal and economic problems as to the mutual relationships, duties and rights of the recipients. A corporation was formed by special charter in the State of New York, in May, 1904, called the United Engineering Society, to act as the trustee for the three founder societies, and its nine trustees are chosen periodically, three each, by the councils of the Electrical, Mechanical and Mining Engineers, to control the building and regulate its finances. The title of the land rests also in this body corporate. The charter of the society, its by-laws, etc., were given most careful thought by the societies, their legal counsel, the committee as a whole, and in particular by Dr. S. S. Wheeler, to whom the intricate matter was entrusted as chairman of a sub-committee. The first president of the United Engineering Society was Dr. A. R. Ledoux, who was succeeded by the present incumbent of the office, Mr. E. E. Olcott. The society took title to the land on which the building stands in January, 1905, and has since paid interest charges and other expenses during the term of construction. It may be stated that while the charter and by-laws of the society have been framed to protect the interests of the three "Founder Societies," under the gift, careful provision is made also for the welfare of the "Associate Societies," i. e., the numerous other technical bodies occupying the building as their headquarters.

Under such conditions, and with such a house for joint occupancy and use, the national engineering societies should make even more rapid progress in the United States than they have done in the past, while the strength which must naturally come by association will enable the work of all to be the more effective along the special lines of each.

THE ELECTROMETALLURGICAL INDUSTRIES IN 1907

By John B. C. Kershaw, F. I. C.



THE author contributed last year to the May issue of CASSIER'S MAGAZINE an article describing the progress of the more important electrochemical and electrometallurgical industries from the early years of their development down to the year 1906.

In the present article the progress of the electrometallurgical industries during the past year, and the position of these at the present date, are reviewed, one branch of the subject only having been dealt with, in order that the information given may be more detailed and of more practical value to those interested in the new industries.

The Electrochemical Industries in 1907 will be the subject of a second illustrated article, to be published at a later date.

As regards the more notable progress of 1906, the great extension of the aluminium and of the copper refining industries, and the increasing interest in the electric furnace methods of iron and steel refining, may be mentioned. The production of ferro-alloys is another electrometallurgical industry which has shown marked expansion during the past year.

Details of the progress in these, and in other industries, are given under the various headings in the following pages:

ALUMINIUM

The year 1906 has been a most successful one in the aluminium industry, the demand for the metal having been much greater than in the previous year, the prices having ruled high owing to the depletion of stocks, and to the inability of the manufacturers to suddenly increase the rate of production. The reports of the companies presented during 1906 indicate that the industry has now entered upon the profit-making stage of its development, the British Aluminium Company showing a gross profit of £93,296 and the Neuhausen Company a gross profit of £186,000 upon the business of the previous twelve months. Figures for the operations of the French and American companies are lacking, but it is probable that these—if published, would show correspondingly large gains.

All the more important European patents relating to the production of aluminium by electrolysis of a bath of molten cryolite, containing alumina in solution, have now lapsed, through efflux of the period for which they were granted. Only in America is there any hindrance to the commencement of the manufacture by electro-metallurgists in general, on account of the existence of the Bradley patents. These cover the resistance method of heating an electric bath, and have still two years to run. The leading companies engaged in the production of aluminium are, however, all planning large extensions of their works. It is probable that these companies will be able to retain their monopoly of the manufacture for some years, since the mines of bauxite (the mineral from which the pure alumina used in the baths is prepared) are now practically in their hands, and outsiders would have difficulty in obtaining an

adequate supply of the raw material of the manufacture.

As regards the aggregate production during 1906, no official figures can be obtained from the manufacturers, who still maintain a policy of secrecy; but the writer estimates that the output has probably increased from 8000 tons,—at which it was stationary for the period of 1902-1904,—to 12,000 tons, and that during the present year the production of the metal may rise to 15,000 tons. Additional water-power is now being developed by the British Aluminium Company on Loch Leven in Scotland, and also in Switzerland, while the Neuhausen Company has even larger schemes of water-power development in hand on the River Navigense, a tributary of the Rhone in Switzerland. When these schemes are completed a large increase in the annual output of aluminium may be expected. At the present moment an aggregate of 87,000 H. P. is available for production of the metal in the twelve works which are devoted to the manufacture, and this power, if applied entirely to aluminium production, would serve to turn out 21,600 tons per annum. The danger of over-production, as the result of the present boom in the demand for the metal, is, therefore, very real and pressing.

No new uses have been found for the metal during 1906, but the demand from motor car manufacturers, from the iron and steel industry, and from makers of "thermit" and "weldite" preparations has been larger than in previous years. Other applications have also absorbed large quantities of the metal.

The prospects for 1907 are good. Now that the limitations of aluminium are recognized and its mechanical properties are better understood, the prejudices which have hindered its application in the past are being removed, and it is coming into more extensive use as a substitute for copper, tin and zinc, in the metal working arts and industries. Its great affinity for oxygen provides also a series of applications as a reducing and heat producing agent, which are not open to the older metals.

BULLION REFINING

The electrolytic methods of refining silver and gold continue to make progress, the Moebius process being used for silver bullion and the Wohlwill process for gold. In America, the Philadelphia and Denver mints are now equipped with electrolytic parting apparatus, while in San Francisco the government mint is being similarly equipped.

CALCIUM CARBIDE AND ACETYLENE

The calcium carbide and acetylene industries have made slow but steady progress during 1906. Only one works is known to the writer to be now in operation in the United Kingdom, namely, at Askeaton, in Ireland. The greater portion of the carbide used for acetylene generation in the United Kingdom is imported from Norway and from other countries which produce carbide in excess of their requirements. In France the manufacture is stated to be fairly prosperous, a result largely due to the syndicate which controls the output and sales. Resistance furnaces are now used in the French works in place of arc furnaces, an electromotive force of 30 to 40 volts being employed, as compared with 60 volts in the older type of furnace. The mean consumption of carbon electrodes has been greatly reduced by this change, and in the latest form of furnace with resistance heating it is only 20 kilograms per ton of carbide. Another improvement relates to the lime and coke employed in the manufacture, the use of pure and dry raw materials being now regarded as of great importance. The care given to the selection of raw materials has resulted in the manufacture of a much more satisfactory product. Eleven works are in operation in France, situated chiefly around the following centres of cheap water-

power:—Bellegarde, Grenoble, Nice, and Toulouse.

The capacity of these works is stated to be about 40,000 tons per annum. The output in 1906 is estimated to have been only 24,000 tons, the annual consumption in France being about 15,000 tons.

Germany, like England, is dependent upon other countries for its carbide, and in 1905 is stated to have consumed 24,000 tons, of which only one-third was produced at home, the larger portion being imported from Switzerland and Austria. There are reported to be eighty central acetylene-gas generating stations supplying light to small village communities in operation in Germany.

The production and consumption of carbide are larger in the United States than in any single European country, and the output of carbide in 1906 is estimated to have been 25,000 tons, with a consumption rather under this total. Over 220 central lighting installations have been operated in the United States, but it is doubtful if all these are still working.

As regards the utilization of carbide for other purposes than acetylene lighting, the manufacture of calcium cyanamide and the use of acetylene gas for autogenous welding of metals are two applications that have developed during 1906.

CARBORUNDUM

Carborundum is a carbide of silicon made by heating coke sand and sawdust to a temperature of 2500 degrees C. in an electric furnace. It was discovered by E. G. Acheson, and its manufacture is chiefly located at Niagara Falls, where, in 1905, 2,518,000 kilograms were produced. This is a falling off of 659,000 kilograms, as compared with 1904, a result which may be partly due to the commencement of the manufacture by Messrs. Meyer & Schmidt, at Rheinfelden, in Germany, the German patents granted to Acheson having been declared invalid in 1903. In order to meet this competition, the Carborundum Company, of Niagara Falls, commenced, in 1906, to erect in Germany a large plant for the manufacture of grinding wheels and abrasive tools and materials of all descriptions, and it was expected that this new works would be ready for operation early in 1907.

Tucker and Lampen have recently carried out some experiments with this material, and have found that its formation temperature lies between 1600 degrees and 1900 degrees C., and that its dissociation temperature was about 2220 degrees C. These temperatures are lower than those originally given by Acheson.

COPPER

The electrolytic copper refining industry continues to expand in sympathy with the increasing consumption of this metal in the arts and industries, and although the figures for the production in 1906 are not yet published, it seems probable that the aggregate output of raw copper for the past year will reach 750,000 tons, and that of this enormous total about 53 per cent., or 400,000 tons, will have been submitted to the electric refining process. The chief progress in the production of electrolytic copper is occurring in America, extensions of plant in connection with many of the refineries having been carried out during 1905 and 1906. The largest refinery is that of the Raritan Copper Company, which is reported to have attained a capacity of 120,000 tons per annum; the refinery of the Nichols Chemical Company follows, with a capacity of 90,000 tons, while the refineries of the American Smelting & Refining Company and of the Larmar Company each produce at the rate of 54,000 tons per annum. These four refineries thus have an aggregate capacity of 320,000 tons electrolytic copper per annum, and can produce alone more copper than all the refineries of the world produced in the

year 1904. Machines are employed in these large modern copper refineries for much of the work that was formerly carried out by hand labour, the casting of the anodes and charging and discharging of the vats being now effected by mechanical means. In this way, and by the use of higher current densities than were formerly considered possible, the cost of the refining process has been reduced from $19.20 to $8 per ton. A new refinery has been erected at Tacoma, and here a copper and lead ore containing silver and gold is employed as raw material of the process. This is treated by the Bessemer process for renewal of the sulphur, the matte is then smelted in a revolving reverbatory furnace and the anodes cast in the usual manner. The new refinery utilizes 2000 H. P., twenty to twenty-four days being required to produce a cathode weighing 120 kilograms. Another new refinery is being erected by the Mountain Copper Company near San Francisco. As a set-off to these extensions, the refinery of the Anaconda Copper Mining Company, in the Western States, is reported to be standing, and the number of refineries operating in the United States is, therefore, stationary at eleven. According to Carlson, the chief improvement on the chemical side of the process introduced recently has been the addition of a small percentage of hydrochloric acid to the electrolyte. This causes the silver to be precipitated as the insoluble chloride, and avoids the loss which otherwise occurs. As regards the position of the refining industry in Europe, there is nothing new to report, and the number of refineries is believed to remain stationary at 23, distributed as follows:—United Kingdom, 6; France, 4; Germany, 9; Russia, 2; Austria-Hungary, 2. The aggregate output of these 23 refineries is, however, small, and the writer estimates that in 1906 they only produced 50,000 tons of copper, or 12.5 per cent. of the total by the electrolytic method.

FERRO-ALLOYS

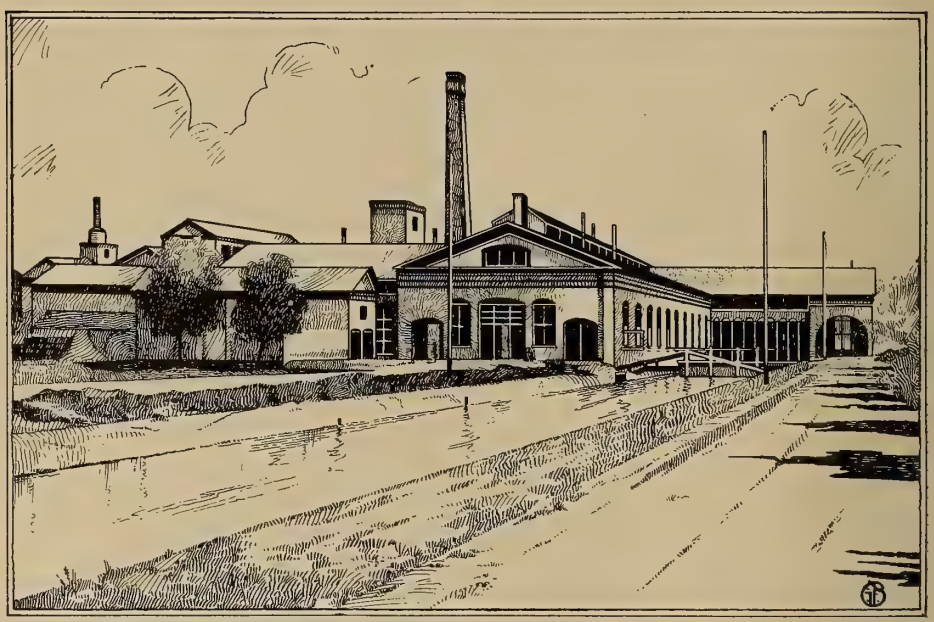
The manufacture of ferro-alloys continues one of the most successful applications of the electric furnace, the increasing use of special steels for high-speed tools and for motor cars having led to a great demand for alloys of iron with those rarer metals, which are found to add greatly to the strength and elasticity of the steel produced. The industry is at present carried on chiefly in France and Switzerland, where many of the water-powers developed during the carbide of calcium boom of 1899-1900 are now being utilized successfully in the production of ferro-alloys. In France especially the manufacture of the alloys is stated to be increasing rapidly, the alloys containing high percentage of silicon and chromium being most in demand.

Ferro-silicon, containing 50 per cent. or more of silicon, is found to be a good deoxidizing agent in general foundry work, and also may be used with success to increase the amount of silicon in the finished iron.

Ferro-chrome is employed for producing chrome steels, the properties of which are now well known. In America the Wilson Aluminium Company are the chief producers of ferro-chrome, their works being located at Kanawha Falls and at Holcomb Rock, in Virginia, a total of 3200 KW. being available in the two factories. The combined output of the two works is about 3000 tons per year. Chrome steel is used most largely in the manufacture of armour plate and projectiles.

Ferro-tungsten and ferro-vanadium are newer alloys which confer upon steel the special properties required for high-speed tools and for axles of motor cars.

Ferro-tungsten is at present produced chiefly at the works of the Société Anonyme Electro-métallurgique, at Ugine, in Savoy. This company has two other works in the same neighbourhood, and utilizes 18,000 H. P. in the manufacture of ferro-alloy by the Girod furnace and pro-



THE KJELLIN STEEL WORKS AT GYSINGE, SWEDEN

cess. The annual output of the three works is given by Dr. Hutton as follows:—

Ferro-silicon, 6000 tons; ferro-chromium, 2000 tons; ferro-tungsten, 800-900 tons; ferro-molybdenum, 50 tons; ferro-vanadium, 5 to 10 tons. The total value of these alloys is stated by the same authority to be over £360,000 per annum, tungsten and molybdenum being very expensive metals, owing to their comparative scarcity.

The first grade of ferro-tungsten, containing 85 per cent. of the rarer metal, is used for the manufacture of crucible tool-steel; the second grade, containing 60 to 70 per cent. of tungsten, is employed for open-hearth steels. It is noteworthy that a large proportion of the tungsten ores used hitherto as raw material of the manufacture in France and Switzerland have been drawn from America, but no doubt in time this export of raw material will be stopped, and only ferro-tungsten or tungsten steel will be shipped to Europe. In 1905 the American mines produced 803 tons of tungsten in the form of ores. The metal is also found in Spain and Portugal, and the Girod Company have obtained control of mines at Guarda and Puy-les-Vignes, in order to provide against the loss of the American supply.

Ferro-vanadium is at present used only in small quantities, and its production is in the hands of the Girod Company and of the New Vanadium Alloys Company, of Swansea. A plant for producing this alloy has also been erected during 1906 at Newmire, Colorado, by the Vanadium Alloys Company, of New York. Messrs. Willans & Robinson, of the Queensferry Steel Works, North Wales, have, so far, been the chief producers of vanadium steel. Trials of the ternary and quaternary steels made with the addition of vanadium have shown that the steels are specially suited to the demands of motor-car work, and in time the manufacture of ferro-vanadium may, therefore, assume very large proportions.

GRAPHITE

This material has been manufactured in the electric furnace by the Acheson process at Niagara Falls for several years, the production in 1905

being about 2000 tons. The greater proportion of this output is used for electrochemical and electro-metallurgical work, the artificial graphite made by the Acheson process having many properties which render it specially suitable for use as electrode material.

For the year ending July 1, 1906, the International Acheson Graphite Company sold 3,404,171 pounds of graphite in the form of electrodes, in addition to large quantities for other purposes. During 1906 Acheson has widened the field of application for artificial graphite by producing a soft modification, that previously produced in the ecletric furnace having been hard and unsuited to many purposes. It is expected that this new variety of artificial graphite will prove a keen competitor of the natural product, especially as it is said to possess great uniformity of composition.

IRON AND STEEL

The year 1906 has been characterized by great activity in connection with the commercial development of the electric furnace methods of iron and steel production. It is only possible in the present article to give a very brief sketch of the present position of the industry, since a whole article might well be devoted to the review of progress in this one branch of electrometallurgy alone.

The Heroult steel refining process is in operation at La Praz and Froges, in France; at Kortfors, in Norway; at Remscheid, in Germany, and at Syracuse, in the United States. The last-named plant has been erected by the Holcomb Steel Company, and is designed for the production of 80 tons of steel per day. The metal charged into the electric furnaces is previously heated in open-hearth furnaces of the Wellman type. The plant has been in operation since April, 1906, with most successful results, and it is hoped to obtain considerable reduction in the cost of current required for the refining process by using superoxidized steel from the Wellman furnace as charging material.

The Ramscheid Works has been in operation since February, 1906. The furnaces are of 30-40 cwt. capacity, and each charge requires from two to two and one-half hours for completion of the refining operation. The raw material costs from 45 to 60 marks per ton, and the final product 90 to 100 marks per ton, this being for second-quality steel. The working costs, therefore, lie between 40 to 45 marks per ton. It is expected that by use of large furnaces these costs will be considerably reduced, and a 1000-H. P. furnace is now under construction.

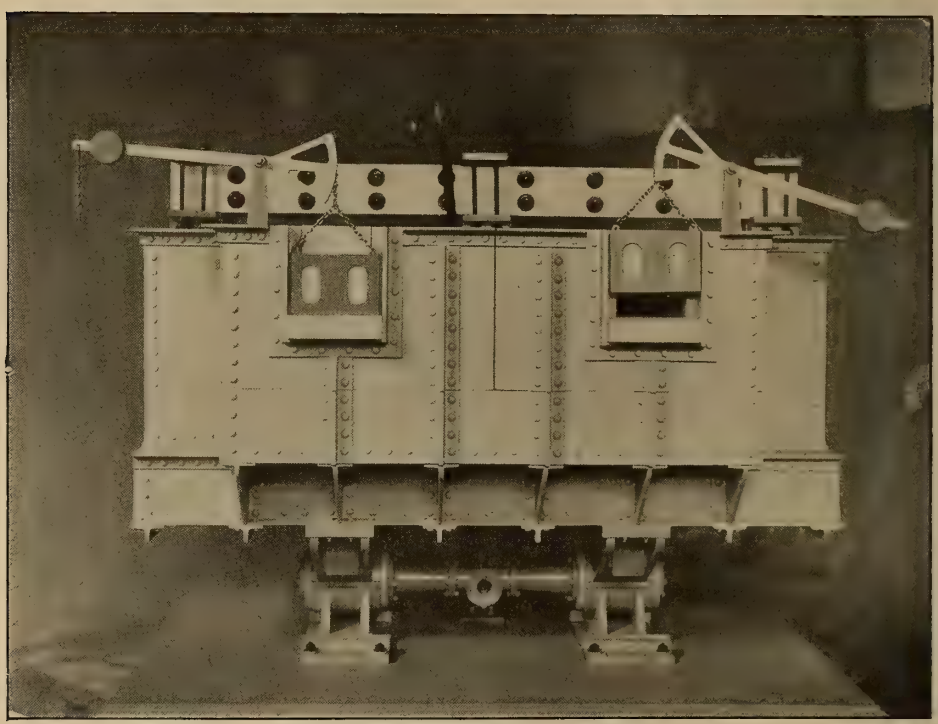
The Keller steel refining process is being operated upon an industrial scale at Livet and at Kerousse, in France, and also at the large steel works of Messrs. J. Holzer & Co., at Unieux, Loire. The latter is the first trial of the Keller furnace by an independent firm, and details of the results should prove of considerable interest in their bearing upon the future of the process. So far, no information relating to these trials has been published beyond a few facts relating to the plant. The refining furnace is of the tilting type, and weighs, with its cradle, 50 tons. A 1500-H. P. steam-driven generating set supplies the necessary electrical energy (20,000 amperes at 60 volts), and the metal is run into the refining furnace in the molten condition from a Siemens-Martin furnace. An output of 30 tons of steel per twenty-four hours is expected from this furnace.

The Kjellin furnace and process are being worked successfully at Gysinge, in Sweden; at Gurtnellan, in Switzerland; at Vicar's Steel Works, at Sheffield; at Krupp's Steel Works, Essen, in Germany, and also at the Araya Iron Works, in Spain, while in America the Colby furnace, of similar design, has been operated for some time past at Philadelphia, with successful results. The Kjellin furnace is of the induction type, and

offers many advantages over the direct-current resistance and arc types of furnace for melting and refining steel, chief of these being the absence of electrodes and the reduced wear and tear upon the furnace structure. The disadvantage of the induction furnace is the smaller range of temperature as compared with the arc-type furnace. Time alone will show which furnace is the better adapted for the production of special steels.

The Stassano furnace is being operated by the Italian Government at the Royal Arsenal, Turin, and also by an independent company, the "Forni Termœllectrici Stassano," with works at Turin, while at Alberville and Ugine, in France, the Girod furnace has been experimented with.

As regards the direct production of iron or steel from the ore, electric methods have made less progress. At Livet, in France, the Keller elec-



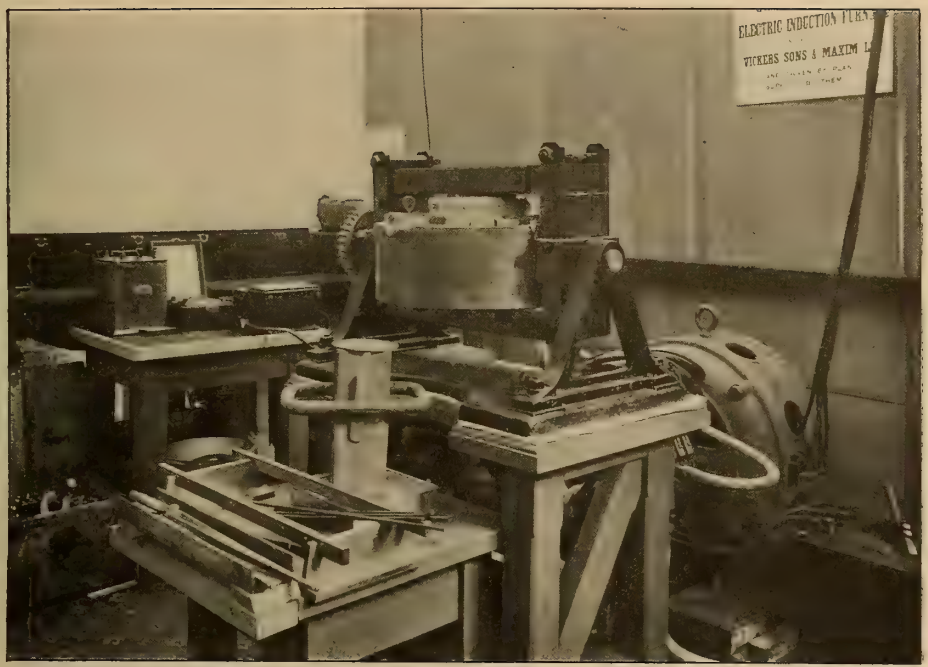
THE GIN ELECTRIC FURNACE, TILTING TYPE

At the present moment the use of the induction type of furnace appears to be developing the most rapidly.

The Gin steel refining furnace is undergoing trial at Plettenberg, in Germany, while plans for erecting similar furnaces at St. Léger, in France; at Sastajo, in Spain, and at steel making centres in Italy and Hungary are under consideration. The latest form of Gin steel refining furnace is of the tilting type, and in some respects has little to distinguish it from the Heroult furnace.

tric smelting furnace has been operating for some years, and a 2000-H. P. furnace, designed for the production of 20 tons of grey pig-iron per twenty-four hours, was under construction in 1906. It is noteworthy, however, that no independent firm has yet erected an electric smelting furnace of the Keller type either in France or in any other country.

The Heroult smelting furnace and process has been thrust into prominence during 1906, owing to the trials carried out by the Canadian Government at Sault Ste. Marie, un-



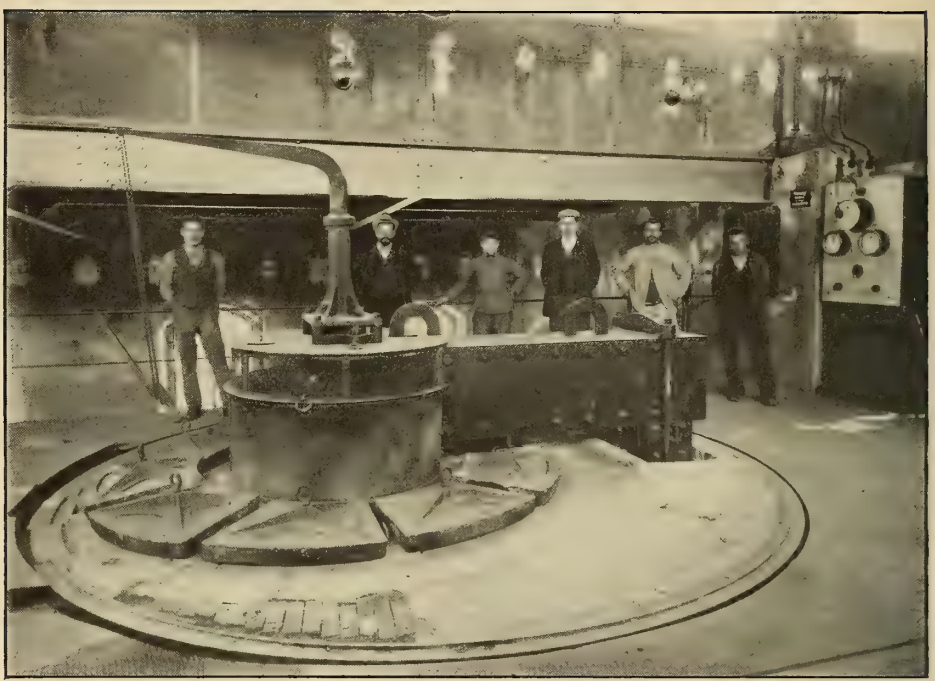
THE KJELLIN INDUCTION FURNACE AT SHEFFIELD

der the personal supervision of M. Heroult.

During these trials 50 tons of pig-iron were made in 150 runs from the ores of the district, and the results are claimed to have been entirely satisfactory. M. Heroult, basing his estimate on these trials, asserts that good pig-iron can be produced in his furnace at Sault Ste. Marie at a cost of $10 per ton. An experimental installation of the Heroult smelting furnace is now being erected by the Shasta Iron Company, in California, and more definite information will shortly be available relating to the prospects of electric smelting in America. In the meantime, the Canadian Government trials at Sault Ste. Marie, and similar trials carried out at Portland, Ore., by Dr. Day, of the United States Geological Survey Department, have, unfortunately, attracted the attention of various company promoters, and unscrupulous attempts have been made to use the results obtained for the creation of a small boom in wild-cat schemes for erecting electric iron smelting works.

It is, therefore, necessary to state once again that the use of the electric furnace for smelting iron ores is still entirely in the experimental stage of its development, and that it is only the application of electricity to the refining process in steel manufacture which has entered upon the second and more lucrative stage of its history. Even in this field of utility it is doubtful whether all the furnaces and processes now being tried will yield adequate pecuniary returns to their inventors and owners. The question of patent validity has yet to be settled, and it is noteworthy that several of the refining furnaces patented in different names are closely allied in structure and in methods of working.

A period of costly litigation, therefore, will probably follow the present period of industrial development, and, in the writer's opinion, some of the patents are likely to be declared invalid before this period is ended.



THE KJELLIN FURNACE IN THE WORKS AT GYSINGE

NICKEL

Nickel is now produced electrolytically by three companies, namely, the Allgemeine Electrometallurgische Gesellschaft, of Papenburg, Germany; the Orford Copper Company, of the United States of America, and the Canadian Nickel Company, of Sault Ste. Marie, Canada. The first-named company employs the Hoepfner process, details of which were given by the present writer in the May, 1906, issue of this magazine. The smelting works of this company are about to be removed to Emden, in order to save transport charges.

The Orford Copper Company has only recently taken up the production of electrolytic nickel, and is reported to be using a "secret" process, but the following details concerning it have been published. The electrolyte is nickel chloride solution. The cathodes are thin sheets of nickel, measuring $36'' \times 48''$, and coated with graphite; the average purity of the deposited nickel is 99.5 per cent. The anodes are made from the nickel sulphide, obtained in the well-known "tops and bottoms" method of separating copper and nickel sulphides; but no details have been published of the methods now used for converting the nickel sulphide into the corresponding chloride.

The process in use at Sault Ste. Marie is stated, on what appears to be good authority, to be the Hybinette process, covered by United States Patent 805,969, of November, 1905. The anodes are cast from the alloy containing nickel and copper obtained by smelting the copper ores of the Soo district. The electrolyte consists of a dilute solution of nickel sulphide, containing a small quantity of boric or phosphoric acid. The cathodes are thin sheets of copper, greased and held in wooden frames, to prevent buckling. These are placed inside porous bags formed of two thicknesses of cotton cloth, and the flow of nickel sulphate solution is directed into the cathode compartments formed around the cathodes by these cloth diaphragms. The level

of solution within and without the bag is adjusted so that the flow of electrolytic is from the cathode towards the anode. By this device the drift of copper ions towards the cathode compartment is stopped, and only nickel is separated at the cathode. The solution in the anode compartment becomes gradually richer in copper and iron. It is withdrawn continuously from the cell, and is regenerated by passing over slabs of nickel or of a nickel-copper alloy. The copper is deposited and nickel takes its place by what is known as "cementation," and after removal of the iron by oxidation the solution contains only nickel sulphide, and is ready for use in the cathode compartment of the cell.

TIN

The methods of recovering tin from tin cuttings and scrap by electrolytic stripping have now to compete with purely chemical methods of performing the same operation, and the electrolytic detinning industry is not, therefore, progressing at its former rate. The method of stripping tin from iron sheet by the use of dry chlorine gas has been patented by Goldschmidt in Germany and by Kuegelgen and Seward in America, and there is no doubt that this method has much to recommend it, both as regards simplicity and economy of operation. Goldschmidt and Weber have recently patented an addition to the original chlorine process of some importance, namely, the use of water for washing the iron after the tin has been removed. (United States Patent No. 836,496, 1905.) As an application for some portion of the surplus chlorine produced by the electrolysis of chloride solutions the production of an hydrous tin chloride from tin scrap deserves attention, and the process is already being worked in certain electrolytic alkali works. In America the year 1906 has been marked by the delivery of judgment in the litigation between the Vulcan Detinning Company and the American Can Company. The last-named company purchased from Goldschmidt the right to work his detinning process in the United States and Canada by a license dated October 17, 1904, and

THE KJELLIN FURNACE AND LADLE AT THE GYSINGE WORKS

the judgment referred to was in favour of their claim to be the rightful owners of the process, as regards its industrial use in America. In view of the extended application of chemical methods for detinning the scrap, the value of the monopoly of Goldschmidt's electrolytic process is, however, now of somewhat diminished value.

ZINC

No striking progress has been made during 1906 in the application of electrolytic or electro-thermal methods to the problem of zinc extraction. The de Laval furnace and process have been in use at Trolhattan, in Sweden; but it is stated that this process is now being operated at Hafslö in Norway, and that the Trolhattan plant has been transferred to the new works. No details of this works are, however, available for publication, beyond the fact that raw zinc and not the ore is used as charging material for the electric furnace.

In Italy, E. Ferraris, of Monte-Poni, is carrying out trials with a similar furnace and process. This investigator read a paper upon the scientific and costs aspects of the electrothermal method of zinc extraction before the Sixth International Congress of Applied Chemistry at Rome, in May, 1906. The cost of the electrothermal process was estimated by Ferraris at 40 lire per ton of calamine. This paper, however, contained little information respecting the author's own experiments, and in a more recent communication Ferraris states that he is not yet in a position to report upon the success or otherwise of his trials of electric furnace methods at Monte Poni.

The Hoepfner process, which is electrolytic, is in operation at Hruschau, in Austria, and at Winnington, in England. The writer believes that no extensions of plant for working this process have occurred for some years.

The Swinburne-Ashcroft chlorination process is being worked at Weston Point, but the writer is unable to say whether the scale of operations has been increased beyond the 30 tons of ore per week referred to in the last report. As pointed out in the May, 1906, issue of this magazine, zinc chloride is the final product of the process at present, and the electrolysis of the fused salt for production of metallic zinc is not carried out at Weston Point. A detailed account of the experiments upon this subject was given by Mr. J. L. F. Vogel, in a paper read before the Faraday Society on May 15, 1906. As regards electro-galvanizing, there is nothing new to report during 1906.

THE IRON-ORE SUPPLIES OF GREAT BRITAIN

IS THERE CAUSE FOR ANXIETY?

By T. Good

A QUESTION of the greatest interest to British investors, iron and steel manufacturers and engineers,—a question, indeed, of national importance,—is that of the future supplies of iron ore. Unfortunately, there seems to be a prevalent uneasiness in some quarters concerning this problem of British iron ore resources, and from time to time ominous warnings are heard from some of those claiming to be authorities of the rapidly approaching exhaustion of the supplies of this valuable raw material of industry, just as, a few years ago, we were presented almost daily with predictions of a coming coal famine, and with graphic pictures of the consequent doom of Great Britain as a manufacturing nation. But the report of a Royal Commission served to dispel anxiety concerning coal. Need there be anxiety about iron ore?

The possibility of an early iron famine was raised about a year ago by the president of the Iron & Steel Institute, Mr. R. A. Hadfield. That note of warning, uttered with moderation, provided a certain school of sensational journalists with a text, although, undoubtedly, Mr. Hadfield's object was to promote the purchasing, or leasing, of certain foreign and Colonial deposits of ore by capitalists, as reserves for the future use of British furnaces, and not to inspire alarm. At any rate, some leading men have been alive to the possible needs of the future, and have become owners, or lessees, of vast ore fields abroad, although there appears just now to be danger of German speculators forestalling British-ers in the east of France, where some newly discovered deposits are available.

However, the fact remains that some journalists seized upon Mr. Hadfield's remarks and turned them into "copy" of an alarmist character. No less a journal than *The Times* published in its *Financial Supplement,* an article which raised the "iron famine" question in its most pronounced form; and Mr. Money, M.P., of the *Daily News,* and other writers sounded the same note. I do not mean to infer that Mr. Money is a sensational journalist; I merely mention his name in order to show how the predictions of a coming iron famine, backed by a wealth of statistics, caused alarm in quarters not technically interested in iron.

The writer of *The Times* article,—an article which has since been much quoted,—told us that "at the increasing rate of consumption there would not be, according to competent authorities, enough ore in the British Isles to keep our furnaces employed for more than twenty years." This kind of statement, appearing in any journal of high repute, is as unfortunate as, in my opinion, it is unfounded.

In the first place, *The Times* writer must have been without adequate knowledge of his subject when dealing with the alleged "increasing rate of consumption" of British ores. During recent years there has not been an "increasing rate of consumption" of domestic iron ore in Great Britain, for the growing requirements of the furnaces have been met by increased supplies from abroad. As a matter of fact, the consumption of

British iron ore has been steadily decreasing for more than twenty years,—from about 18,000,000 tons a year in the early "eighties" to an average of about 14,000,000 tons a year since the present century commenced. There has been a slight increase in the output of British iron ore mines during the last few months,—since *The Times* article was written,—but the output is not yet near so great as it used to be. Nor is it likely to be. The increasing rate of consumption to which *The Times* writer alluded by mistake related to foreign, not domestic, ores, imports of which, in thirty years, have risen from less than 1,000,000 tons a year to as much as 7,800,000 tons for last year. On the average, about 80 per cent. of the imported ores used in Great Britain comes from Spain.

But after issuing a solemn warning of the depletion of the domestic iron ore resources in about twenty years' time, *The Times* writer went on to state that the best ore fields of Spain "would be exhausted within the next ten years!"

Now, with all due respect to *The Times,* and to those who made capital, journalistically, out of *The Times* article, also to those "competent authorities" quoted by *The Times* writer, I venture to say that such statements,—statements which form a much too prominent feature of the British press,—are not in strict accordance with ascertained and indisputable facts; that they are put forward without adequate allowance for possible future discoveries of iron ore, and without due regard for the probability,—nay, the certainty,—of the introduction of improved methods of mining, smelting, and manufacturing which will bring about the profitable utilization of ores too inferior to be workable under present-day conditions. Moreover, the persistent publication of such pessimistic views concerning a subject of which no one can claim full knowledge has the effect, if not the intention, of weakening confidence and checking the investment of capital in British industries.

There are no facts within our knowledge to warrant belief in the probability of an iron famine within our time; and surely future generations, with an ever-increasing development of science and with an ever-growing power over natural difficulties, may safely be trusted to work out their own industrial and economic salvation in their own times. I would recommend those who imagine an iron famine to be within measurable distance to compare their gloomy prognostications concerning iron ore with those equally mournful prophecies of an early coal famine, already alluded to, which were so largely indulged in a few years ago. Just as fear in the case of coal has been proved groundless, so could anxiety in the case of iron be removed by inquiry.

In Great Britain to-day there are something like 1,000,000,000 tons of iron ore "in sight." From this already ascertained stock we are drawing but 14,000,000 tons annually, and so, at this rate, we have sufficient ore for the next seventy years. But who dare assert,—as, indeed, the pessimistic assume,—that no more deposits of this mineral will be found in our islands? Why, the best-informed journalist in London didn't know there was coal in Kent until the engineers discovered it! And so it is with iron ore. In the few brief months which have elapsed since *The Times* writer gave us his solemn warning, backed by "competent authorities" and corroborated by statistics, no less than five important discoveries of iron ore have been made within the British Isles,—in Lancashire, in Cumberland, in Staffordshire, in Derbyshire, and in Ulster. At least one of these is officially reported as "of great magnitude and excellent quality." As yet we have tapped but the mere crust of the earth, and only a few portions even of that. Yet there are those claiming to be authorities who, for want

of fuller knowledge and wider outlook, or for want of better occupation, do all they can to frighten both capital and labour out of this country by sensational stories of the approaching end of industrial resources. Yesterday it was a coal famine; to-day it is an iron and copper and gold famine, all threatening together; to-morrow it will be—what? A labour famine perhaps, because last year's emigration statistics show a record exodus.

It may be true that, so far as we know officially, there are only some 250,000,000 tons of the "best" ore left in present workable ore fields; but it is forgotten that the "estimate" upon which this calculation is based was arrived at fifty-six years ago. Five fresh discoveries have been made within the last six months. Even if we accept these figures as they stand,—granting that we have no more than these anciently estimated 250,000,000 tons of "best" ore left in these islands,—it is known that there are positively enormous reserves of inferior ores which, although not profitabble to work under existing conditions, will in all probability be exploited as successfully by improved methods in the future as we now work the best ores. It must not be assumed that we have reached the limits of human knowledge,—of the faculties of research—of the powers of invention.

The latest authoritative information we have on the subject of iron-ore resources is contained in a report presented to the Swedish Parliament a little over a year ago by the Swedish Geological Survey Department. But we must not accept even this as final. From this report, however, we learn that the known iron ore reserves of Great Britain are only slightly less than those of the vast United States of America; that we are not drawing from our deposits at half the rate which our American rivals are from theirs; that in the matter of foreign supplies we are most favourably situated, and that we need not cease to be a great iron-producing nation within the next 250 years. This Swedish report gives us the following figures:—

	Known Deposits in Workable Ore Fields in Millions of Tons.	Present Annual Output of Ore Fields in Millions of Tons.	Present Annual Home Consumption of Ore in Millions of Tons.
United States..	1,100	35	35
Germany.....	2,200	21	24
Great Britain..	1,000	14	20
France.....	1,500	6	8
Spain.....	500	8	1
Russia.....	1,500	4	6
Sweden.....	1,000	4	1

It must be remembered that since this report was presented both output and consumption have been increased in the principal iron countries in consequence of the 1906 "iron boom." On the other hand, additional ore deposits have lately been found in America, Britain, Germany, France, and several other countries, and we have also to note that some of the best authorities,—more especially American authorities,—have declared that the compilers of the Swedish report underestimated the known deposits of all countries except their own. But the report is of the greatest value none the less.

The principal British iron ore field is that of Cleveland, North Yorkshire, and so far from the conditions of this field providing cause for anxiety, we are told by no less an authority than Mr. J. Stephen Jeans, in his recently published "The Iron Trade of Great Britain" (Methuen, London), that the future of Cleveland is better assured than that of any other (known) iron district in Europe."

I have referred to the probable future working up of ores now classed as inferior. In Cleveland, although many years must pass before the best ores in that district are exhausted, this process has already commenced,—aided, it is only fair to mention, by easier mining royalties than exist in most other parts of Britain. The supply of what is called "shale" ironstone is practically un-

limited, and six or seven mines there are working successfully in "shale." As cheaper methods of mining and manufacture come to be devised further development of "low grade" mineral extraction will certainly occur, in Cleveland and elsewhere, and vast deposits which now lie untouched for various reasons will feed the furnaces of the future. But we have by no means come to the end of our discoveries of good ore yet.

Now with regard to foreign and Colonial supplies of ore, how do we stand? At present Spain is the country upon which England chiefly draws. For several years we have received from that country between 4,000,000 and 5,000,000 tons of iron ore annually,—about 80 per cent. of our total foreign supplies, and more than half the output of the Spanish mines. Recent imports of Spanish iron ore have reached

1904	4,600,000 tons.
1905	5,700,000 tons.
1906	5,900,000 tons.

while the total imports have been:—

1904	6,100,000 tons.
1905	7,300,000 tons.
1906	7,800,000 tons.

What are Spain's resources? We have it on official and governmental authority that the already ascertained deposits of iron ore in Spain, at the present rate of output, will not be exhausted before the end of the century. A large portion of those rich deposits in Spain is already owned, or leased, by British iron and steel manufacturers. And in addition to an estimated 500,000,000 tons of ore in the now workable fields of Spain there are vast deposits yet untapped, and large portions of the country unexplored for minerals. This Spanish ore, yielding 50 per cent. of iron, can be brought to England, and, in some cases,—as at Jarrow, for example,—can be landed right alongside the blast furnaces at a freightage of little more than 4 shillings per ton, which is considerabbly less than the cost of transit enjoyed by our American rivals in carrying their own ore from Lake Superior mines to Pittsburg furnaces. With improved methods of handling, loading and discharging of cargoes, with vessels still better designed and adapted for this particular trade,—as are those on the Great Lakes of America, for instance,—even this low freightage could be materially reduced.

Mention of transit in America calls for special comment on the problem of iron making. The fabulous natural resources and wonderful powers in general of America have been so widely and loudly advertised that we Britishers are apt to forget the unique advantages which we ourselves possess. We hear much, for example, about the abundance and cheapness of coal and iron ore in the United States, but it is forgotten, or ignored, that while the principal ore deposits of America have been placed by Nature 1000 miles distant from the coal fields, and that the American furnaces, on account of the coal, are situated from 400 to 500 miles distant from the seaports (an important point in connection with the problem of international competition), we in Great Britain have the ore, the coal, the furnaces, and the ships practically side by side. All the advantages are not on the side of our big rivals. They enjoy no monopoly either of Nature's bounties or of human capabilities.

Take the case of Germany. That country, like America, has gone ahead of England in iron production, but not on a *per capita* basis. What natural conditions exist in Germany superior to our own? If our rivals have lower mining royalties and cheaper railway rates than we have, surely that is our own, and not Nature's fault. But after all that can be said, even about cheap carriage in Germany, the natural conditions in that country are such that it costs from 6s. to 7s. per ton to carry most of the ore from the ore regions to the coal and furnaces, while in this country the cost is in but few cases more than 1s. 6d. per ton. Thus, not only is England better situated naturally than her chief

rivals, both German and American, in the matter of domestic supplies, but also better situated geographically in the matter of over-sea supplies. At any rate, it is an indisputable fact that Great Britain can profitably produce pig-iron, the foundation of her steel and engineering trades, just as she can build ships, at a cost below that of other countries. That is the cardinal point—the supreme fact—in the issues involved. And if her competitors are making rapid progress, that need cause little alarm. We, too, are capable of progressive efficiency,—human and mechanical.

So far as future supplies of ore are concerned, in addition to our home reserves and those of Spain, there are other supplies within easy reach. Sweden is likely to be able to furnish large quantities. The country is within short distance, has fully 1,000,000,000 tons of the "best" ore "in sight,"—little of which it appears to need for its own consumption,—and has huge reserves of second and third-rate ores.

Norway, still nearer home, has not less than 200,000,000 tons of good ore "in sight," much of which is already in the possession of British capitalists, and vast portions of the country are yet untapped. The Dunderland Iron Ore Company, constituted a short time ago, has now nearly 100,000,000 tons of ore within its reach, and is making preparations to export to Britain on a large scale.

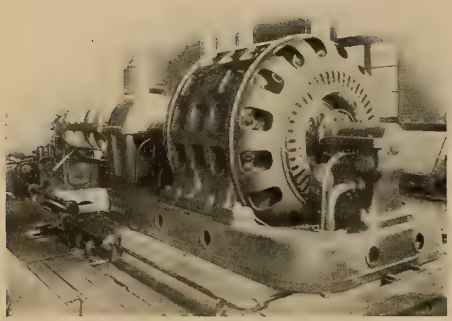
And just as it already pays to bring ore from Spain and Scandinavia to England, to be worked up by British labour and British coal, so it is quite reasonable to assume that future generations of Britons, should near supplies ever fail them, will just as easily obtain ore from Algeria, Tunis, Nigeria, Greece, Turkey, Soudan, New Caledonia, Newfoundland, Canada, Australia, New Zealand, India, and even China,—countries in which are stored for future use immeasurable quantities of iron ore.

In British colonies and dependencies there are vast reserves of iron ore and other raw materials,—in India, Newfoundland, and Canada there are rich veins of iron ore close by the coasts which, with proper organization, could be shipped to Britain at very low cost, should ever the necessity arise,—deposits, the existence of which, apart from those nearer home, should serve to banish the fears of those who imagine that Britain's industrial doom is at hand. Even now a cargo of iron ore is on its way to the Clyde, if not already arrived, from Australia.

If economic or industrial decadence does really threaten Great Britain in any way, we have no right to blame Dame Nature, who has, indeed, bestowed blessings upon us lavishly, but had better look to our own shortcomings and antiquated methods of production and business.

THE COMING OF AGE OF ELECTRICAL ENGINEERING

By B. A. Behrend



ELECTRICAL engineering, in the sense in which we are using this expression, is a very young art among the industries, and yet this youthful art has impressed itself so strongly upon the engineering world that no one has any doubt as to the name referring to the building of electric generators and motors and the transmission of energy. The older arts of telegraphy and telephony have never been comprised under this term, and they have long since come of age and taken their places alongside of other tried-out lines of industry.

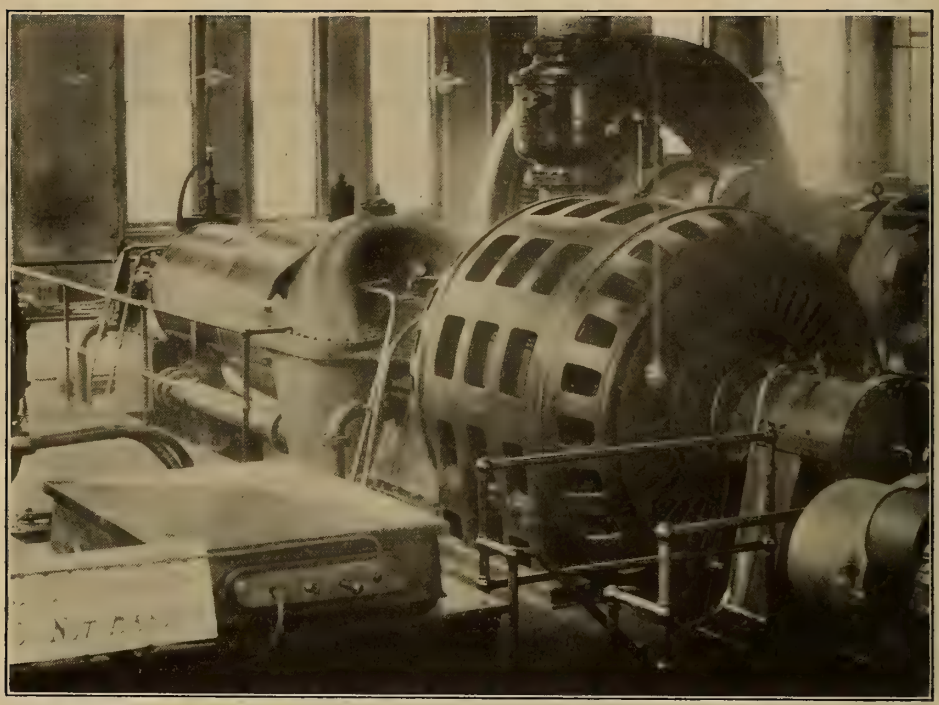
The electric transmission of energy is synonymous with electrical engineering. It received its first practical demonstration by the transmission of 50 H. P. over a distance of 5 miles to the town of Soleure, in Switzerland. This small plant is a mile-stone in the development of engineering, and its success has inspired with confidence those engineers and designers who were engaged in the conceiving, planning, and creating, of apparatus needed for the accomplishment of transmitting safely, to places of utilization, the power which could be conveniently generated only at considerable distance from these centers of consumption.

Long strides have been taken during these twenty years. The world beheld with wonder the transmission of 300 H. P. over a distance of 125 miles on the occasion of the Electric Exhibition at Frankfort-on-the-Main, in 1891. Shortly afterwards the water power of the Niagara River was turned to account, the power being transmitted from the falls to Buffalo and other towns in the vicinity. It is no longer a matter of speculation, but the power of the falls has reached the heart of the State of New York, as far as the city of Syracuse. The power of Shawinigan Falls is transmitted over a distance of 80 miles to Montreal, and the country west of the Rocky Mountains to the Pacific Coast is covered with high-potential transmission lines which far outclass, as to distance, those of the East.

Inventive genius and the designers' creative ideas have kept step with the rapid growth of electrical engineering in the development of prime movers. The classic names of James Watt and George Stephenson, associated for all time with the reciprocating engine and the steam locomotive, are in danger of being classed with those of Heron, of Alexandria, and Archimedes, of Syracuse, if evolution continues to proceed as rapidly as it has done during the coming of age of electrical engineering. The steam engine in large sizes is

gradually, but very energetically, being replaced by the steam turbine, on the one hand, and by the internal combustion gas engine, on the other hand. The steam locomotive also has a dangerous rival in the electric locomotive, which, for the hauling of trains through tunnels, has already replaced the steam locomotive. It is especially in this direction that we must look for new creative ideas which will open up such a field as was opened up by the discovery of polyphase currents. There is, in the realm of ideas, a distinct difference between "natural' ideas and "forced" ideas. The natural idea may be likened to a plant growing under favorable conditions and adapting itself to its environment; the forced idea may be likened to a plant raised in a hothouse, with the exclusion of such conditions as might have a tendency to prevent its development. The natural idea will survive; the forced idea will go to the wall; but it is often only after extended experiments conducted on a large scale have been laboriously completed, that we realize that an idea has been followed out which could have lived only under particularly favourable conditions, such as are not usually found in practical operation.

In contemplating the history of the development of the utilization of alternating currents, the single-phase system has appeared to be an almost ideally simple system. It is only too obvious that, if power could be safely transmitted and utilized in an economical manner, and by means of simple mechanical apparatus, the generation and utilization of single-phase currents would soon replace the polyphase system. Such attempts were made fifteen years ago, and, after considerable effort, most engineers abandoned hope in developing a practical system of transmission of energy by means of single-phase currents. The experience gained during the past fifteen years with polyphase currents and the many opportunities afforded the engineer for comparing the single-phase machinery, generators, and motors, with their polyphase cousins, have led to an attitude of skepticism towards single-phase current. The very much reduced output of both generators and motors if operated single-phase; the reduced efficiency; the impaired regulation; the increased heating, and the lesser stability of single-phase motors and generators, connected with the increased cost as produced by the greater amount of material required; these form the main reasons for inducing me to call the recent attempts which have been made in the utilization of single-phase currents, a forced idea. Though no man is wise enough to predict with any degree of certainty the future of any particular system which has not been given thorough trial, yet the consolidated experience of the engineer often enables him to predict, with a tolerable amount of certainty, the future prospects of new ideas. That our trains will be propelled by means of electric power, sooner or later, we state with a measure of apodeictic certainty, as we have seen the continued inroad of the electric application of power where other means were previously employed. There is, however, a great difference between a statement of this sort and a statement regarding the means by which this will be accomplished. Fifteen years ago the possibilities of polyphase systems were clearly seen by engineers competent to judge, although the apparatus developed at that time was still rather inefficient. Our attitude towards apparatus generating and utilizing single-phase currents is slightly different. Our efforts have not been crowned with success as regards the building of economic single-phase generators and motors whose characteristics may be favourably compared with those of polyphase machines. If single-phase currents are to be used successfully, a new creative idea must be introduced which will do away



ALLIS-CHALMERS 1500 KILOWATT STEAM TURBO GENERATOR

with some of the disadvantages peculiar to the present single-phase apparatus. Those gigantic experiments to be conducted on the New York, New Haven & Hartford Railroad are being watched with the respect due an enterprise of such magnitude, and with the hope that, even if the system should not be all that its ingenious designers had expected, it may yet lead on to ideas which will finally solve the problem of electrically operating the present steam railways of the world. A measure of skepticism in this direction has the further advantage of making the designers and inventors look for some other system in case of limited success or failure of the system adopted.

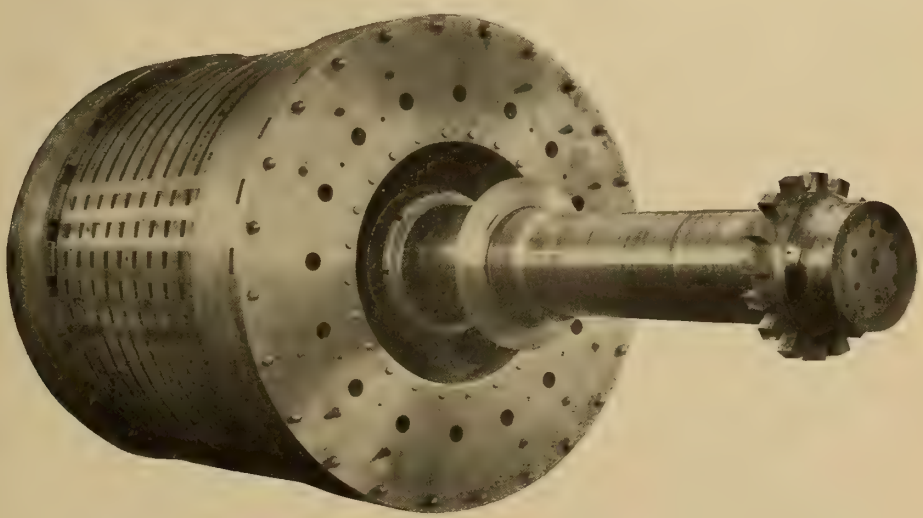
The opening of the Simplon Tunnel and the use of three-phase currents for the locomotives which haul the trains between the two countries of Switzerland and Italy is an interesting example of how little agreement has been reached in regard to the kind of electric power best adapted to heavy electric traction. In America, the two most recent and most noted installations for the electric propulsion of trains are the terminal equipment of the New York Central & Hudson River Railroad and the equipment of the New York, New Haven & Hartford Railroad. The former is using direct current, the latter is using single-phase alternating current. The most noted and also most recent application of electric power to the propulsion of trains in Europe is to be found at the Simplon, and here three-phase alternating-current locomotives have been used. It would thus appear that the three systems are about equally well, or equally poorly, adapted to the propulsion of trains. Under such conditions, the question can hardly be considered solved, and much remains yet to be done towards its rational solution.

The utilization of direct current of 1000 volts, or thereabouts, in connection with electric railway appa-

ratus, is based upon the well established experience with railway apparatus of 600 volts, and, though lacking in new ideas, it may be looked upon as merely an extension of the present system over a larger range by means of an increase in voltage. There is no reason why this system should not be successful within the limits of its application. The great problem of electrically propelling railroad trains is still looking for solution by means of a new creative thought.

In the category of the forced ideas is to be placed the idea of transmitting large volumes of power by means of high-potential direct current. That such things can be done is unquestionable, but it is equally unquestionable that to do them by means of high-potential direct current is unreasonable. The intuition of the experienced engineer, which is, as it were, the consolidated experience of many years, will guard him against becoming too deeply wrapped up in schemes of this sort. We heard of high-potential direct current when the problem of the best means of transmitting the power of Niagara was discussed; we have heard of it again recently in connection with the transmission of power of the Victoria Falls. These are ideas which cannot hold their own, though they persistently crop up like weeds which would fain take the place of useful vegetation.

If it may be said with justice that the requirements of electric apparatus have wrought a revolution in the design of prime movers, it may be said with equal justice that the experience gained by the designers of prime movers has brought about a very thorough-going change in the design of electric generators. Necessity is the mother of invention. The steam engine twenty years ago ran too slow for the electric generator. This led to an increase in speed in the prime mover. No sooner had the engine builder learned to build a high-speed engine than the steam turbine made its appearance, forcing upon the electrical engineer speeds far in excess of those for which he had learned to build electric generators. The steam turbine has come to stay with us, as will be granted by the most skeptical of engineers. The difficulties with its mechanism have been difficulties not at all inherent in the turbine, but difficulties produced by the failure of slight de-



REVOLVING FIELD OF 10,000-HORSE POWER STEAM-TURBINE ALTERNATOR A CHARACTERISTIC FEATURE OF MODERN ELECTRICAL ENGINEERING

tails, such as the fastening of the blades, the putting together of spindles, and the like; features which could readily be improved by more careful attention and better workmanship. With the steam turbine, a promise of large capacity in individual units has been held out to us which will outclass the large power units at Niagara Falls and those in the great power stations of the Interborough Railroad in New York. We no longer talk without substantial foundation when we consider the building of units of 15,000 H. P., or even of 25,000 H. P. Such units will be built in the near future, and they will be more substantial and economical than the smaller units. With the growth of the cities, the power station of the immediate future will contain as many 20,000-KW. units as the power station of to-day contains units of 5000 kilowatts.

The future development of electrical engineering is likely to be influenced by a new idea or discovery, a discovery not unlike Faraday's discovery of electro-magnetic induction. If I may be permitted a prophetic guess in this direction, and if I may be excused for letting my wish be father to the thought, some means of generating direct current without the crude methods employed at present is sorely needed. A method, as yet unknown, for the mechanical generation of direct current without commutators or without a multiplicity of sliding-contact rings must be invented, in order to give the art a new impetus. The next twenty years will be as full of surprises as the past, and it appears almost futile to speculate upon the possibilities of electric power in view of such marvelous discoveries as have been made in the field of radio-activity.

EFFICIENCY IN STEAM-BOILER PRACTICE

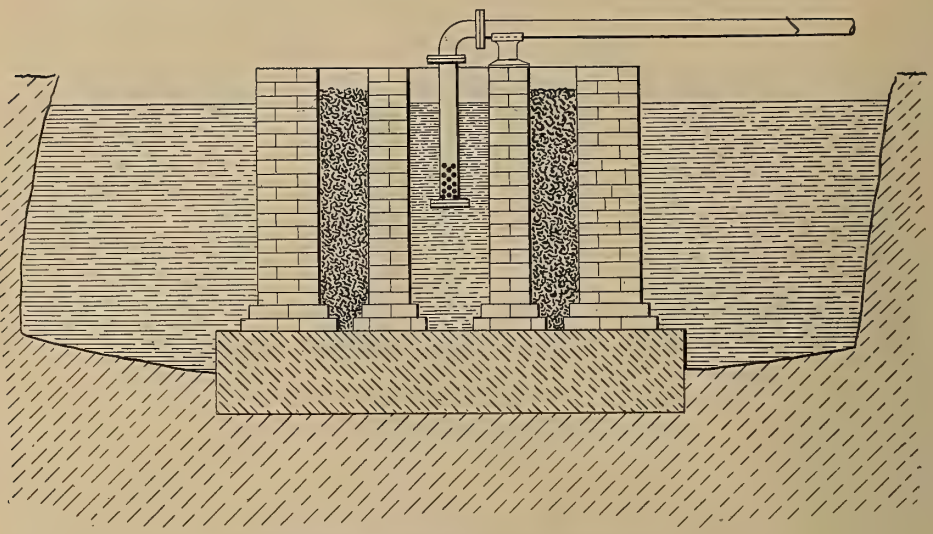
By Percival Cooke

Efficiency is a term variously interpreted according to the viewpoint of the investigator. In the case of engines, boilers, and other motive-power mechanism, it has been found that the apparatus giving the highest thermal efficiency does not always give the maximum economic efficiency, and a machine may be economical in its consumption of heat units and at the same time wasteful of money. In this paper and in its successor the efficient performance of steam boilers is treated from the position of the manufacturer, to whom the term means the relation of the money he gets out to the money which he puts in, a matter in which he is vitally interested.—The Editor.

I.—THE PRINCIPLES OF EFFICIENCY

OF the many important problems to be confronted in the practice of steam engineering, few possess so many features of interest, or present so wide a scope for the exercise of skill and ingenuity, as that of the achieving increased efficiency and greater economy in the practical working of the steam boiler. The acme of perfection in steam boiler practice is at present far from being attained, more particularly so in actual working and management than in design and construction.

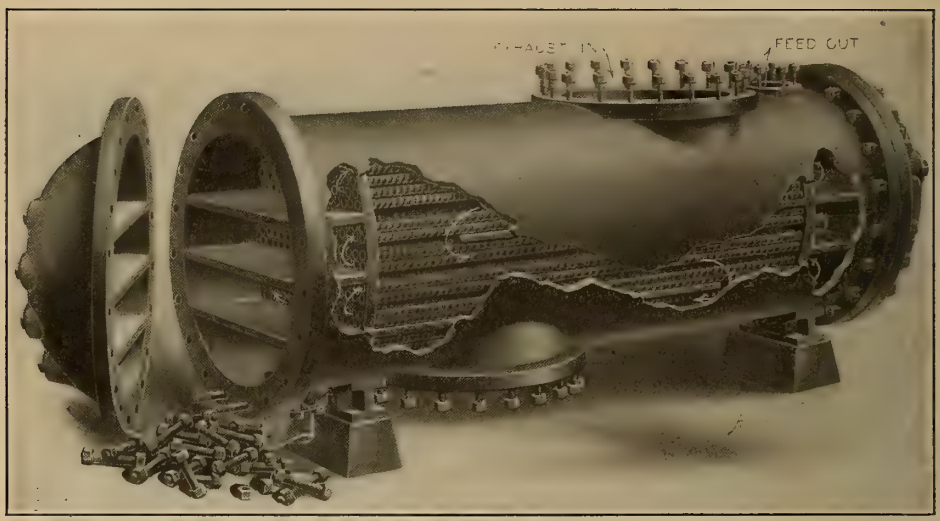
No boiler, however well designed and constructed, will operate efficiently if not properly worked and cared for. One of the most important essentials to the efficient working of a boiler is a thoroughly reliable and intelligent fireman; but such men, unfortunately, are often difficult to find. When found, however, they are in every way worthy of appreciation; but, at the same time, boilers should not be left entirely in the charge of such men, however much above the average of their class they may be, for steam plant, especially if of large dimensions, should be under the supervision and control of a skilled engineer. Before proceeding further, it may, perhaps, be advisable to define the meaning of the term efficiency as used in this article. Theoretically, the efficiency of a boiler is the ratio of the actual quantity of heat transmitted to the water to the total quantity of heat available for transmission. But the term conveys also a broader and more comprehensive meaning than this, and, briefly, expresses the relative condition of a boiler with reference to its ability to perform its duties consistently and economically, denoting particularly freedom from calcareous deposit or other incrustation, hot feed-water, continuous feeding, rapid water circulation, clean and effective heating surfaces and fire grates, and the maintenance of the proper conditions of combustion in the boiler furnaces. It is in this sense that the term efficiency will be used practically throughout this article. It is of the first importance that a suitable quality of fuel be used if steam raising is to be economically and satisfactorily accomplished, and in this respect it should be borne in mind that the lowest-priced coal is not necessarily the most economical. The steam-raising value of coal should not be based merely upon its calorific power, as the quantity of ash and other incombustible matter it contains is also a factor of importance. Coals of inferior quality often yield from 19 per cent. to 35 per cent. or more of ash, and, bearing in mind that this involves much labour and expense in its removal, it



SETTLING POND AND FILTER FOR FEED WATER

becomes evident that a low-priced coal yielding, say, 20 per cent. of ash, may in reality be more expensive than a higher priced coal yielding a residual of only 5 or 6 per cent. Dirty, unwashed coals of low calorific value, leaving a large percentage of ash, are by far the most troublesome to deal with, entailing, as they do, almost incessant labour on the part of the fireman, so that it is in many cases practically impossible for all the requirements of the boiler to be given full and proper attention. As a general rule, coals yielding more than 11 per cent. of ash should not be used for boilers fitted with ordinary furnaces and fire grates, even when working under forced draught. For these furnaces clean-washed coals are the most suitable and satisfactory; but almost any reasonably clean and inexpensive coal may be advantageously burnt in specially constructed forced-draught furnaces fitted with finely-divided, self-cleaning grate bars. The most reliable basis for comparing the relative value of different coals, apart from the all-important coal bill, is by means of carefully conducted evaporation tests, the results of which will be of the highest value in enabling conclusions to be drawn as to the most suitable coal to use in any particular case. The condition of the feed-water as it enters the boiler is a factor of the greatest importance, which influences considerably the degree of efficiency to be attained in the process of steam raising. In all cases feed-water should be clean and hot; especially should it be free from oil and grease. These elements are generally to be found in water which is heated by exhaust steam, being carried over by the steam from the engine cylinder. They may be removed by oil filtration, but the best way is to remove the cause, which may be effected by the adoption of continuous sight feed lubrication for the engine. Town reservoir water requires little or no purifying, but canal water and well water should be carefully treated and cleansed before use, containing, as they invariably do, large quantities of both suspended and dissolved impurities. Suspended matter may be removed by filtration, which effectually clears the water, but has no effect in relieving it of its soluble matter. When water is used from settling and cooling ponds it is a good plan to construct a rough filtering arrangement in the pond, such as

GREEN ECONOMIZER AS ARRANGED IN OVERHEAD FLUE
E. GREEN & SONS, LTD., WAKEFIELD. GREEN FUEL ECONOMIZER COMPANY, MATTEAWAN, NEW YORK



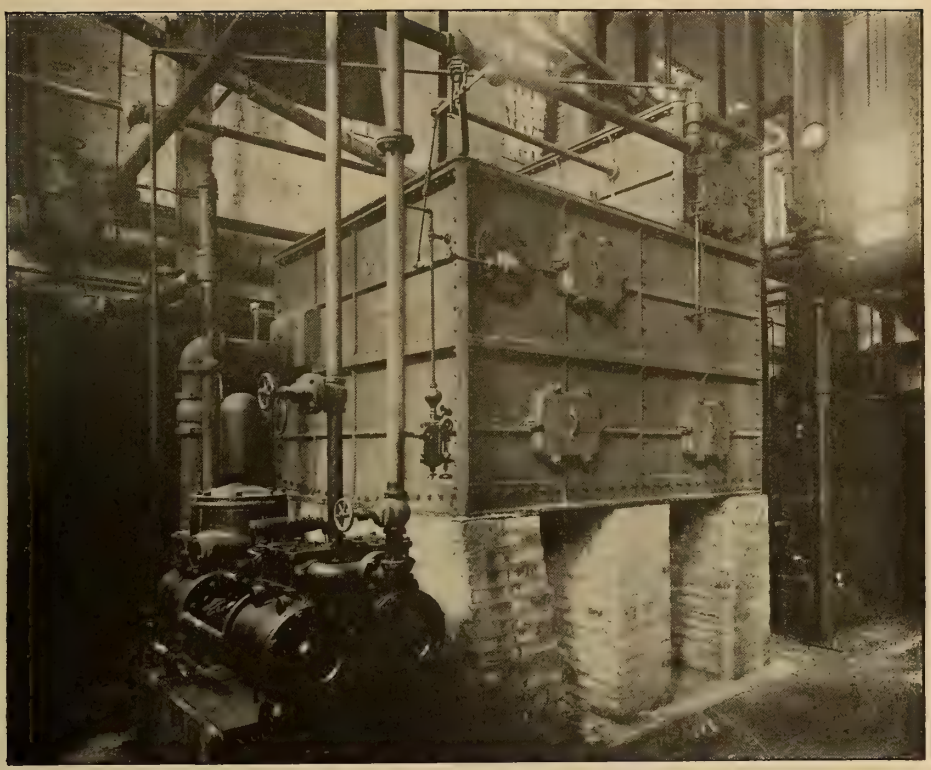
WAINWRIGHT EVEN-FLOW FEED-WATER HEATER, ALBERGER CONDENSER COMPANY, NEW YORK

shown in the illustration, which is circular in plan. The walls are of ordinary brickwork, with all vertical joints left open about half an inch. The space between the walls is filled in with ashes, or any suitable material which may be at hand. This filtering medium requires periodically changing. The suction pipe is closed at the end, being perforated. as shown, to about twice its area. This, however, is only a primary arrangement, and all water from such a pond should pass through a good feed-water filter before entering the boiler. As regards impurities held in solution, it is essential that their nature and composition be thoroughly and correctly known before effective steps for their removal can be taken, and for this purpose it is advisable, and, in fact, necessary, that the feed-water be chemically analyzed periodically. These soluble impurities vary with the source and nature of the water, but generally consist of the carbonates of calcium and magnesium and the sulphate of calcium. The carbonate salts are practically insoluble in water, but are held in solution by carbonic acid gas, or carbonic anhydride, CO_2, which, when combined with water, absorbs the carbonates, which are deposited on the expulsion of the gas. Both the carbonate and sulphate impurities may be removed, either by chemical precipitation or by heating the water, the former being the most effective and reliable, although both methods are widely employed in practice.

One of the oldest and simplest methods of softening water is Clarke's process, which is too well known to call for description here. This process, however, is ineffective in the case of sulphate waters, as it merely precipitates the carbonates. Under ordinary circumstances the best way of dealing with boiler feed-water is to precipitate the impurities by the addition to the water of sodium hydrate, NaOH, better known as caustic soda, which absorbs the carbonic anhydride, forming sodium carbonate and water, the chemical reaction being expressed by the equation:

$$\underset{\text{Carbonic Acid}}{H_2CO_3} + \underset{\text{Sodium Hydrate}}{2NaOH} = \underset{\text{Sodium Carbonate}}{Na_2CO_3} + \underset{\text{Water}}{2H_2O}$$

the calcium and magnesium carbonates, no longer capable of remaining in solution owing to the withdrawal of the carbonic anhydride, being deposited. Meanwhile, the sodium car-



SORGE-COCHRANE WATER PURIFIER AT THE WORKS OF THE FRANKLIN IRON MANUFACTURING COMPANY, FRANKLIN SPRINGS, NEW YORK. BUILT BY THE HARRISON SAFETY BOILER WORKS, PHILADELPHIA

bonate formed as above combines with the calcium sulphate contained in the water, depositing a further quantity of calcium carbonate, and leaving sodium sulphate in solution, according to the equation:

$CaSO_4$	+	Na_2CO_3	=	$CaCO_3$	+	Na_2SO_4
Calcium		Sodium		Calcium		Sodium
Sulphate	+	Carbonate	=	Carbonate	+	Sulphate

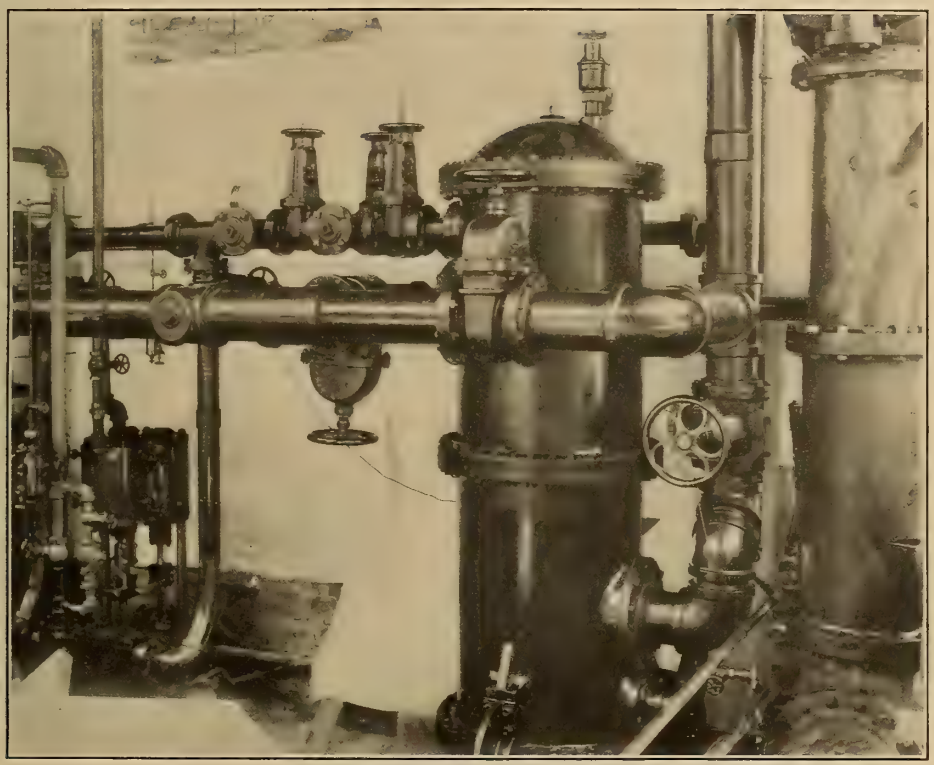
The sodium sulphate, being a highly soluble salt, remains in solution indefinitely, being redissolved at the same rate as it is deposited by evaporation. When commercial sodium hydrate is used its degree of purity should be carefully ascertained, for when in an impure state it may contain matter which would have an injurious effect upon the material of the boiler. It is itself highly corrosive, and when used to excess its effects are as harmful as they are beneficial when properly used. When economically practicable, the cleansing reagents should be pure. Sodium carbonate is often used for softening feed-water, in which case only the later stage of the operations above described takes place. The purifying reagents should be introduced into the feed-water continuously, and not at intervals, to obtain the best results. The exact quantity necessary can only be ascertained by the chemical analysis of the feed-water. Precipitation should not be allowed to take place in the boiler, this being obviously not the proper place for the deposition of sediment. When water is treated cold, or comparatively cold, a certain amount of time is necessary for the settling action to take place, according to the quantity being treated, and it is consequently advisable to employ two settling tanks of as large a capacity as convenient, water being drawn off

SCALED PANS TAKEN FROM A HOPPES LIVE STEAM FEED-WATER PURIFIER AFTER 30 DAYS' RUN, HOPPES MANUFACTURING COMPANY, SPRINGFIELD, OHIO

from one whilst the contents of the other tank are undergoing purification. Water softening plant has, of late, come well to the front, and in cases where large quantities of impure water require dealing with much advantage and ultimate economy accrues to their use. All secret compounds and patent compositions for the treatment of feed-water should be rigidly avoided, these having in several cases been proved to contain ingredients harmful to the boiler, apart from which, there being no universal specific for impure water, it is altogether contrary to scientific principles that any particular compound is capable of properly purifying varying qualities of water. When water is heated to a temperature of about 325 degrees F., the carbonate and sulphate salts become insoluble, and are precipitated, the deposition of the carbonates taking place almost instantaneously, and the sulphates being deposited comparatively slowly. The deposition of the latter may be hastened by heating to a still higher temperature if practicable. This method of purifying feed-water is widely used, and is both economical and efficient when properly carried out. It is, perhaps, the most convenient and least troublesome method for application on a small scale, as in the case of only one or two boilers.

Apart from considerations of cleanliness, feed-water should always be heated to the highest practicable temperature before being fed into the boiler. This may best be accomplished by passing the water through a hot-well heated by exhaust steam, from which it may be pumped into an economizer of suitable size, and from thence into the boiler. If the hot-well is of good construction, the water may be heated as high as 200 degrees F. or even higher, and its subsequent passage through the economizer should raise its temperature very nearly to the boiling point

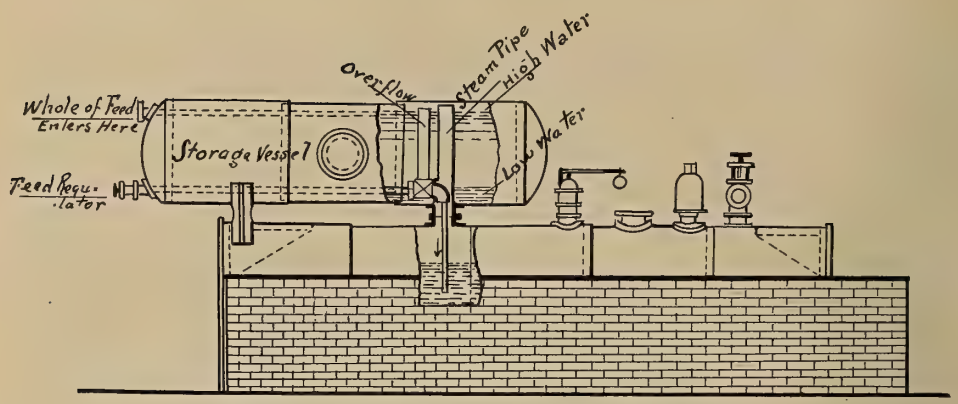
of the water in the boiler. The value of high temperature feed-water can scarcely be over-estimated, and is, in fact, the foundation of efficiency in steam raising. In ordinary practice, no boiler whilst at work should at any time be fed with cold water, as, besides entailing considerable waste



WAINWRIGHT VERTICAL FEED-WATER HEATER, 2000 H. P., INSTALLED AT THE AMERICAN WALTHAM WATCH COMPANY, WALTHAM, MASS. ALBERGER CONDENSER COMPANY, NEW YORK

of fuel, the water, by reason of its greater density, gravitates to the bottom, impeding circulation, and causing local contraction in the lower parts of the boiler, whereby its durability is more or less impaired. It is, in fact, unfair and unnecessary treatment of any boiler to continually work it with cold water. If a boiler is to work with any degree of success, good water-circulation is imperative, and this can only be obtained by using hot feed-water.

Recent experiments have shown that fuel economy may be gained by the use of live steam for feed-water heating. Superficially, this appears improbable, and has consequently been the subject of much discussion, although it has latterly been generally admitted, and in several cases proved in practice, that such economy may be effected. Looked at in an ordinary light, it is evident that the steam cannot impart more heat to the feed-water than it has itself received by the expenditure of a certain amount of fuel in the boiler furnaces. From whence, then, comes the economy of fuel? The explanation of this apparent phenomenon depends upon the fact that evaporating water, that is, water which is being supplied with latent heat, takes heat approximately twice as fast as non-evaporating water, or water which is being supplied with sensible heat, whereby, owing to the water side of

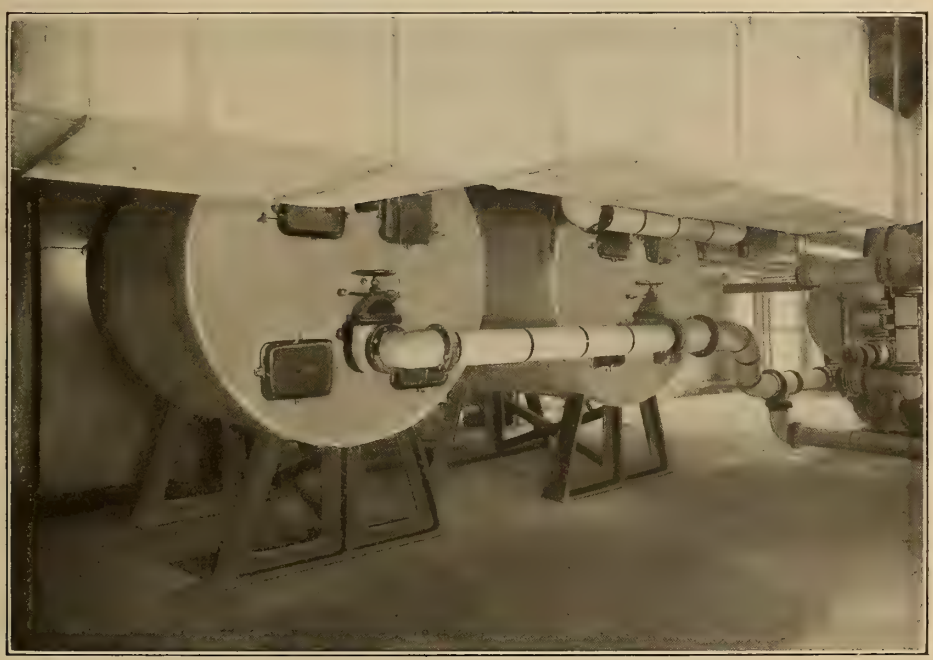


APPLICATION OF THERMAL STORAGE TO A LANCASHIRE BOILER.

the plates being more rapidly cooled by evaporating water, the rate of the flow of heat through the plates is about doubled, and, in consequence, about twice as much heat is required per unit area of heating surface in a given time when putting latent heat into water than when putting sensible heat into water, from which it is obvious that the efficiency of absorption of the heating surfaces is greatly increased, in fact, approximately doubled, less heat therefore passing to waste. The reason why fuel economy is effected by live steam feed-water heating, therefore, becomes obvious when it is stated that the process brings the feed-water almost to the point of ebullition, according to the quantity of steam used, so that practically the whole of the boiler heating surface is being utilized in the production of steam. In a series of experiments carried out by Mr. A. W. Hamilton, of the Belfast Mechanical Engineering Association, the results obtained showed that when the feed-water received 17 per cent. of the total heat required to effect evaporation, the actual reduction in the consumption of fuel was 21 per cent., and when the fuel received 20.4 per cent. the saving effected was 24.7 per cent. Thus it is obvious that whatever source of heat may be used for heating feed-water, considerable advantage and economy is to be gained by bringing the water as near as practicable to the point of ebullition prior to its entry into the boiler, and in all cases where a high efficiency is sought a great effort should be made to secure this advantage. The thermal storage system of heating feed-water, invented by Mr. Druitt Halpin, is, in effect, a system of live steam heating. The illustration shows a Lancashire boiler fitted with thermal storage tank; the tank is placed directly over the boiler, steam from which has access to the storage vessel through a vertical pipe. The storage vessel thus acts as a surface condenser, the feed-water,—the whole of which passes through the vessel prior to entering the boiler,—becoming heated almost to the point of ebullition. The vessel should be kept well covered with non-conducting material in order to prevent loss of heat by radiation.

A steam boiler may be divided into two separate parts, viz., the furnace, or furnaces, and the boiler proper, each of these having its own particular function, that of the furnace being to generate heat by combustion, and that of the boiler to transmit the heat so generated to the water contained within it. Now it is evident that if the function of the boiler is to be properly performed, the heat transmitting surfaces must be in a condition of maximum efficiency, in order that the largest possible quan-

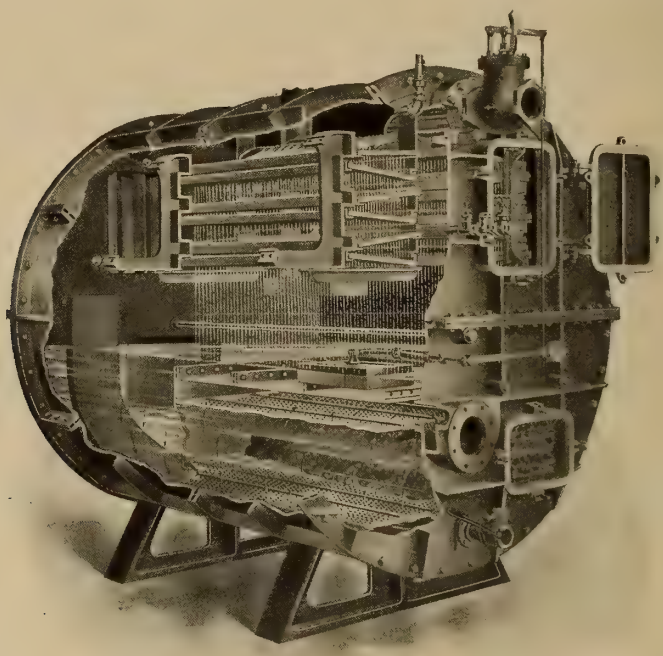
tity of heat may be transferred from the furnace to the water. In other words, the heating surfaces must be thoroughly clean on both sides if they are to be used to the fullest advantage. Soot on the external heating surfaces is a potent factor in reducing efficiency of heat absorption; in some cases the loss of economy due to this cause exceeds the loss due to the presence of scale on the water sides of the surfaces. The diminution of efficiency due to internal incrustation depends largely upon the nature of the deposit. Scale of a calcareous nature, characterized by a large number of interstices, interferes considerably with the transmission of heat; sulphate scale, which is of a more closely formed nature, becomes, to a certain extent, homogeneous with the metal, and retards the flow of heat to a much less extent. Nevertheless, the accumulation of scale, whatever its composition, should not be permitted. On the other hand, however, a thin coating of scale inside the boiler is advantageous in resisting the effects of corrosion. The internal heating surfaces may be kept clean by keeping the water in the boiler in a clean condition, which may be accomplished by frequent and regular blowing-down, twice a day if possible. Special attention should be given to the blowing down of water-tube boilers. The method to be adopted in the cleaning of the external surfaces depends, of course, upon the construction of the boiler. The plates and flues of cylindrical boilers should be swept at regular intervals of from two to four weeks, according to the conditions of working; the tube surfaces of water-tube boilers may in most cases be cleaned by the application of the steam jet, which should be used three or four times a week, or each day, if convenient. When using steam jets for tube cleaning care should be taken that the jet plays between the tubes, and not directly upon them, as this would cause racking strains in the material of the tubes.



WEBSTER FEED-WATER HEATERS, 1500 H. P. EACH, INSTALLED IN THE POWER HOUSE OF JOHN WANAMAKER, PHILADELPHIA. WARREN WEBSTER & CO. CAMDEN, N. J.

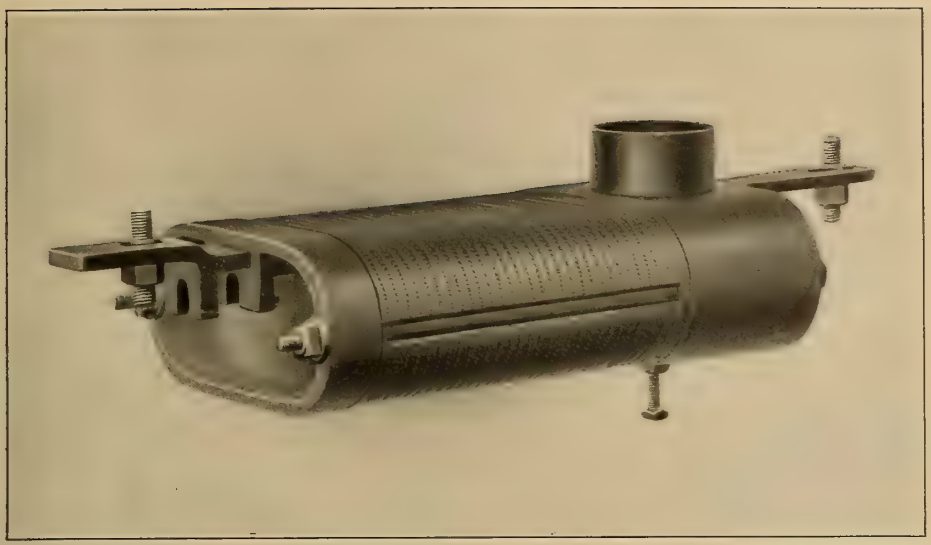
The economic efficiency of a boiler is considerably influenced by loss of heat due to radiation, and in order to minimize this loss all exposed surfaces should be well covered with a good non-conducting material, of a thickness of at least 2 inches. The same also applies to live-steam and hot feed-water pipes, the covering in this case being about an inch and a half in thickness. There are several good composition coverings for boilers, which, however, need not be named here. Asbestos is not an efficient covering unless compounded with some other slow-conducting material; neither should brickwork be used, owing to its tendency to harbour moisture, which may cause external corrosion. Boilers should be given two or three coats of plaster of Paris before applying a covering. Coverings applied in the form of a plaster should be laid on wire netting, in order to facilitate removal when necessary. They may be rendered much more effective by forming an air space between the plates and the covering.

Much trouble is often experienced in steam practice owing to priming, or the production of wet steam, and all boilers not fitted with steam-drying appliances offend in this respect to a certain extent. Excessive priming may be due either to faulty boiler construction or improper management, generally the latter. Priming increases rapidly as the boiler is forced. Continuous feeding, steady firing, the maintenance of a constant water level, and the use of anti-priming pipes are all factors which appreciably minimize the ill effects of priming. The most effective and efficient method, however, of over-



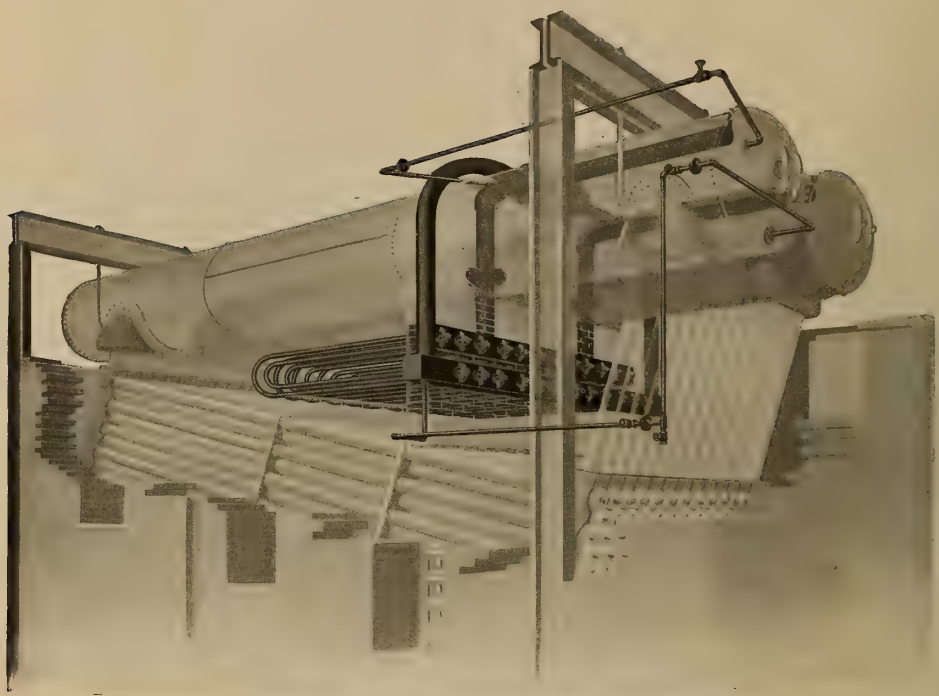
THE WEBSTER FEED-WATER HEATER AND PURIFIER. WARREN WEBSTER & CO., CAMDEN, N. J.

The water is heated and purified while flowing over the pans, and then passes upwards through the filter



THE POTTER MESH SEPARATOR. PLACED INSIDE THE BOILER TO PREVENT WATER FROM BEING CARRIED OVER WITH STEAM. POTTER SEPARATOR CO., NEWBURGH, N. Y.

coming the difficulties caused by priming is to superheat the steam. Considerable economy accrues from this practice, which is fast becoming general. Superheaters, which may be either integral with, or separated from, the boiler, should be placed in such a position that a suitable temperature is always available, and should either be fitted with a simple flooding arrangement or be so constructed that the heat current can be shut off from contact with the superheater when it contains an insufficient quantity of steam to take away the heat imparted to it. Water-tube boilers lend themselves much more readily to the application of superheaters than do ordinary cylindrical boilers, which, when working economically, present difficulties, owing to the high temperature of the return flues and the comparatively low temperature of the lateral flues. When placed in the return flues of cylindrical boilers superheaters are attended by much risk, and their upkeep is costly, whilst when placed in the lateral flues, the advantage gained by their use is, to some extent, minimized if fuel economizers are also used. The Babcock & Wilcox standard type of steam superheater consists of a number of "U"-shaped tubes connected at both ends to manifolds or steam boxes, the upper of which communicates by means of two vertical tubes with the steam space in the boiler drum, the lower manifold being connected, as shown, to the main steam valve. The saturated steam passes from the boiler into the upper manifold, traverses the "U"-shaped tube, during its passage through which it is superheated, and is then delivered from the lower manifold to the steam valve. The free communication between the boiler steam space and the superheater obviates all danger of the pressure of the superheated steam rising above that of the saturated steam. The flooding arrangements consist of a small pipe connecting the water space at the back end of the boiler with the lower manifold, this pipe, which can be partially seen in the photograph, being fitted with flooding and draining valves, by means of which, whilst first raising steam, the superheater and necessary pipes may be filled with water to the same level as the boiler, the superheater thus becoming, for the time being, part of the



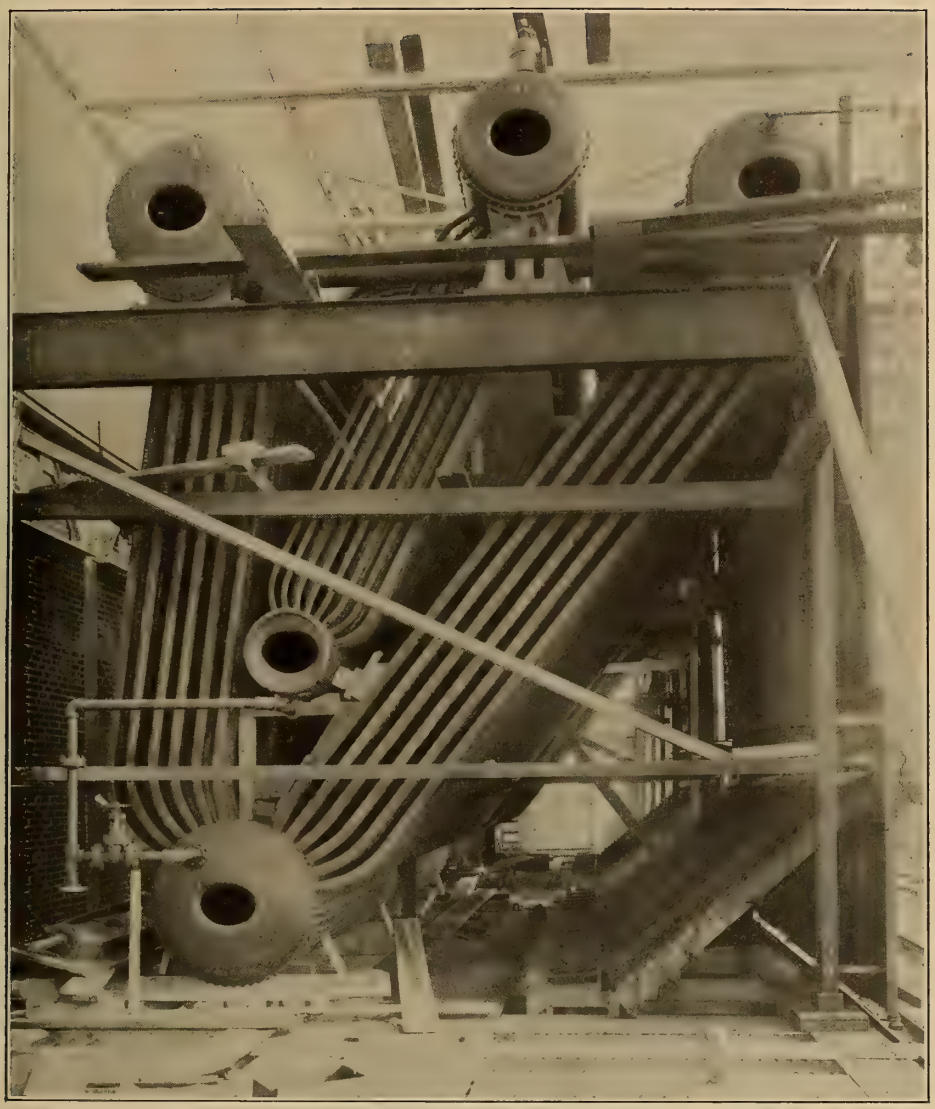
ARRANGEMENT OF BABCOCK & WILCOX SUPERHEATER

boiler heating surface. When steam is up the superheater may be drained through the flooding pipe by means of the drain valve. It will be noticed that the boiler is also fitted with a saturated steam by-pass valve, by means of which a small quantity of saturated steam may be mingled with the superheated steam if desirable.

The Stirling superheater consists of two drums connected by seamless drawn tubes, 2 inches in diameter, the construction being practically the same as the standard design of the Stirling boiler. The drums are divided by partitions within, so that the steam is compelled to make four passes through the tubes, thus prolonging the duration of the passage and contact with the heated surfaces, while in case of emergency the superheater may be flooded and used to generate saturated steam. If it is desired to reduce the degree of superheat, saturated steam may be mixed with the superheated steam in any desired proportions.

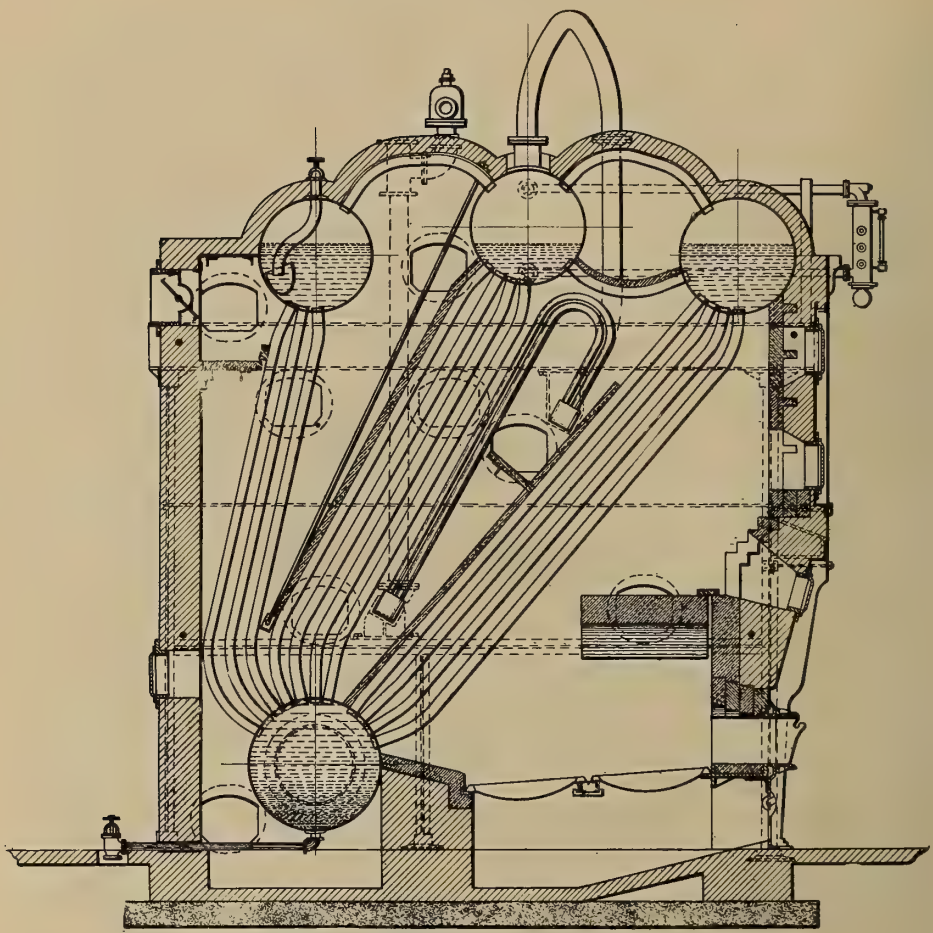
However good the conditions of all other parts of a boiler, true efficiency must ultimately depend upon the conditions under which combustion takes place in the boiler furnaces, and consequently upon the manner in which these furnaces are worked. There are three distinct methods of hand-stoking boiler furnaces, viz., spreading-stoking, coking-stoking, and alternate side-stoking, all of which are extensively used in practice, the first method being the most general. The two latter methods are more efficient, but their successful adoption depends largely upon the skill of the fireman. The precise method to be adopted in any particular case depends, of course, upon the conditions of working and various other circumstances which need not be generalized, but in all cases the principles underlying efficient combustion are the same, and will be explained shortly.

The combustion of coal in a boiler furnace may be readily divided into three stages. Firstly, the rapid emis-



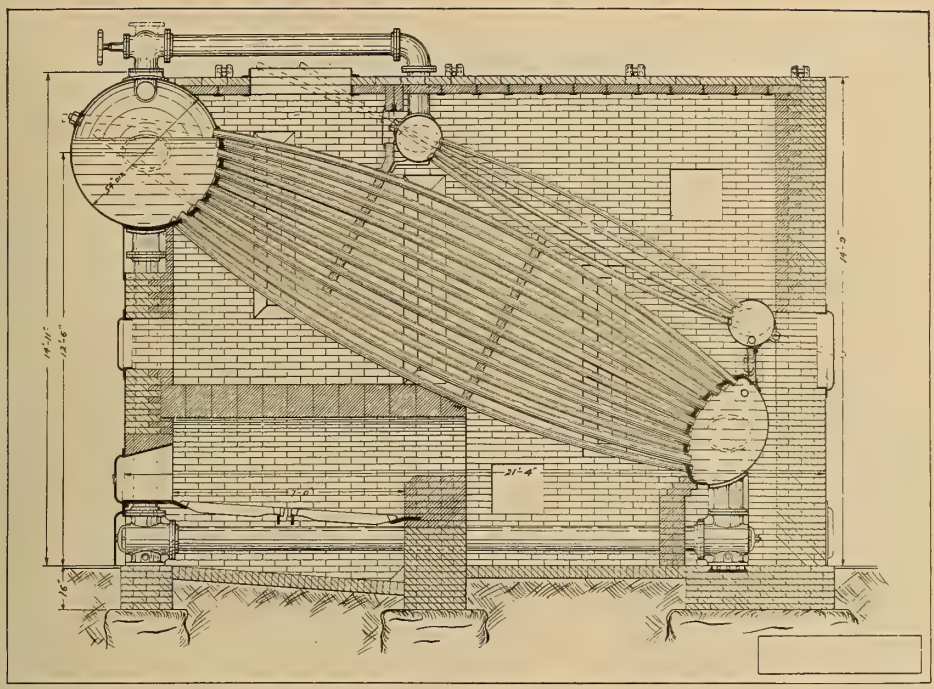
STIRLING SUPERHEATER PLACED IN MIDDLE PASS

sion of the gaseous constituents, of volatile elements of the coal, consisting chiefly of marsh gas, CH_4 and olefiant gas, C_2H_4, this being the coking process; secondly, the partial or complete combustion of the evolved hydrocarbons, according to the quantity of air present, complete combustion yielding water in the form of steam, and carbon dioxide, CO_2; and thirdly, the smokeless and flameless combustion of the fixed carbon, or coke, the products of which are again carbon dioxide. If, owing to insufficiency of air, or the lack of a suitably high temperature in the furnace, or both these causes combined, complete combustion is not effected, part of the gases evolved during the coking stage are only burnt to carbon monoxide, CO, the lowest oxide of carbon, whereby it is evident that, owing to incomplete chemical combination, loss of economy is taking

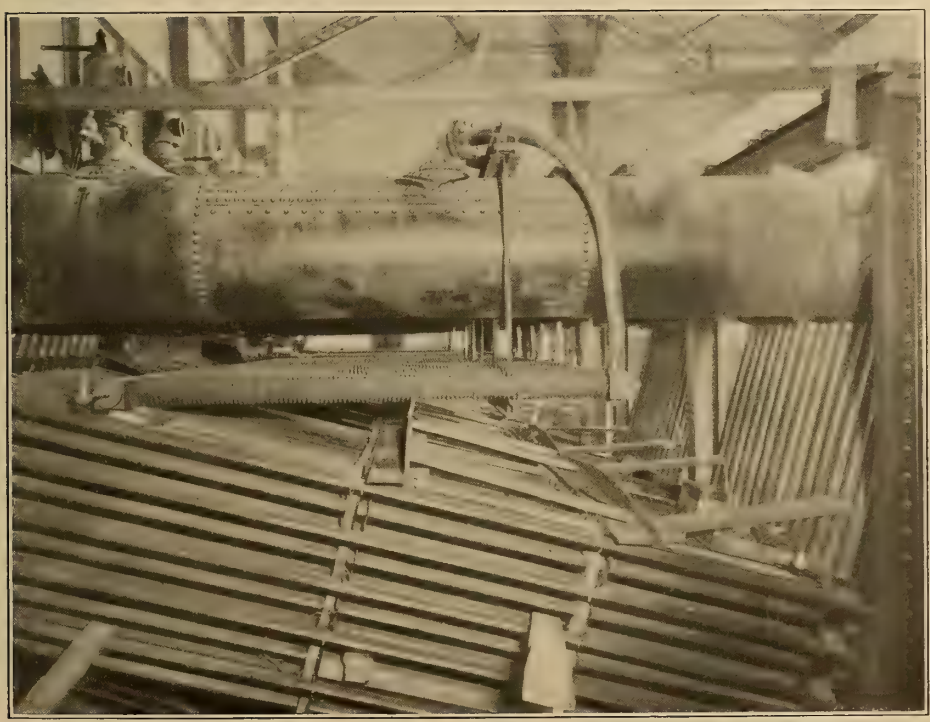


STIRLING U-TUBE SUPERHEATER PLACED IN MIDDLE PASS

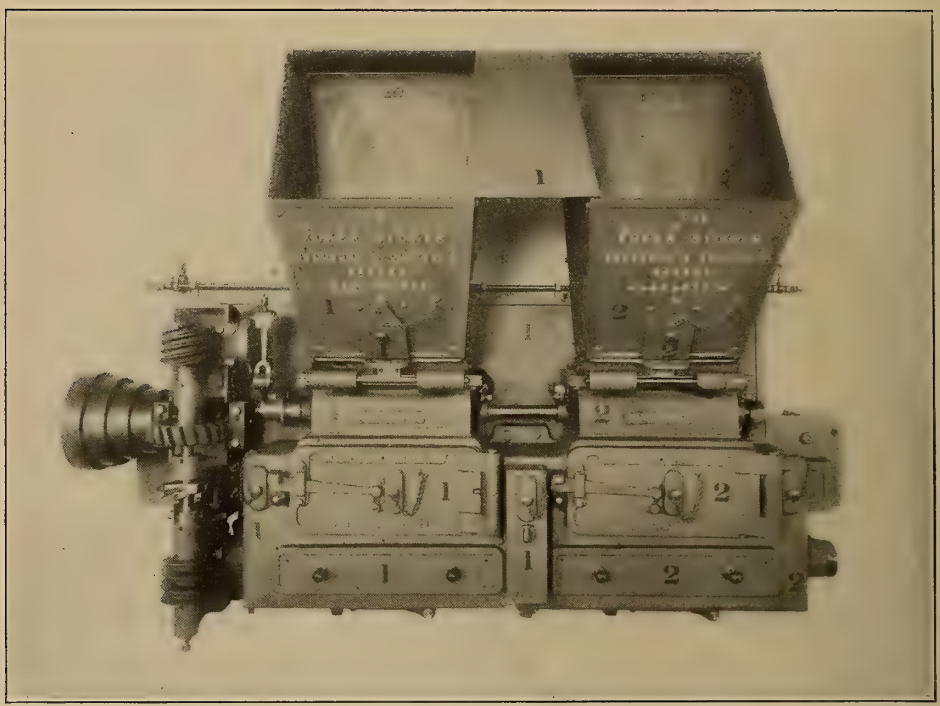
place; the more complete the combination, the greater the quantity of heat produced. Again, if the combustion is incomplete, innumerable finely divided particles of carbon are produced, consequent upon the decomposition of the somewhat unstable carbon monoxide, and also of the volatile gases effected by the combination of the hydrogen they contain with the oxygen of the air present (the combination of these elements taking place much more readily than that of the carbon and oxygen), these particles being carried along with the gases and being partly deposited as soot in the flues and on the boiler heating surfaces, the remainder being emitted from the chimney in the form of smoke, which, if dense or voluminous, is a plain indication of furnace inefficiency. Obviously, then, to obtain the most economical results, the whole, or as large a percentage as possible of the fuel, must be burnt to carbon dioxide, to effect which the furnace must at all times be supplied with the requisite quantity of air. On the other hand, should there be any excess of air, heat which might otherwise be advantageously utilized is carried away and wasted, so that if a maximum efficiency is to be attained the air supply must be correctly adjusted to the requirements of the furnace. Not only must there be sufficient air present, but this air must be brought



MOSHER WATER-TUBE BOILER AND SUPERHEATER. MOSHER WATER-TUBE BOILER COMPANY, NEW YORK



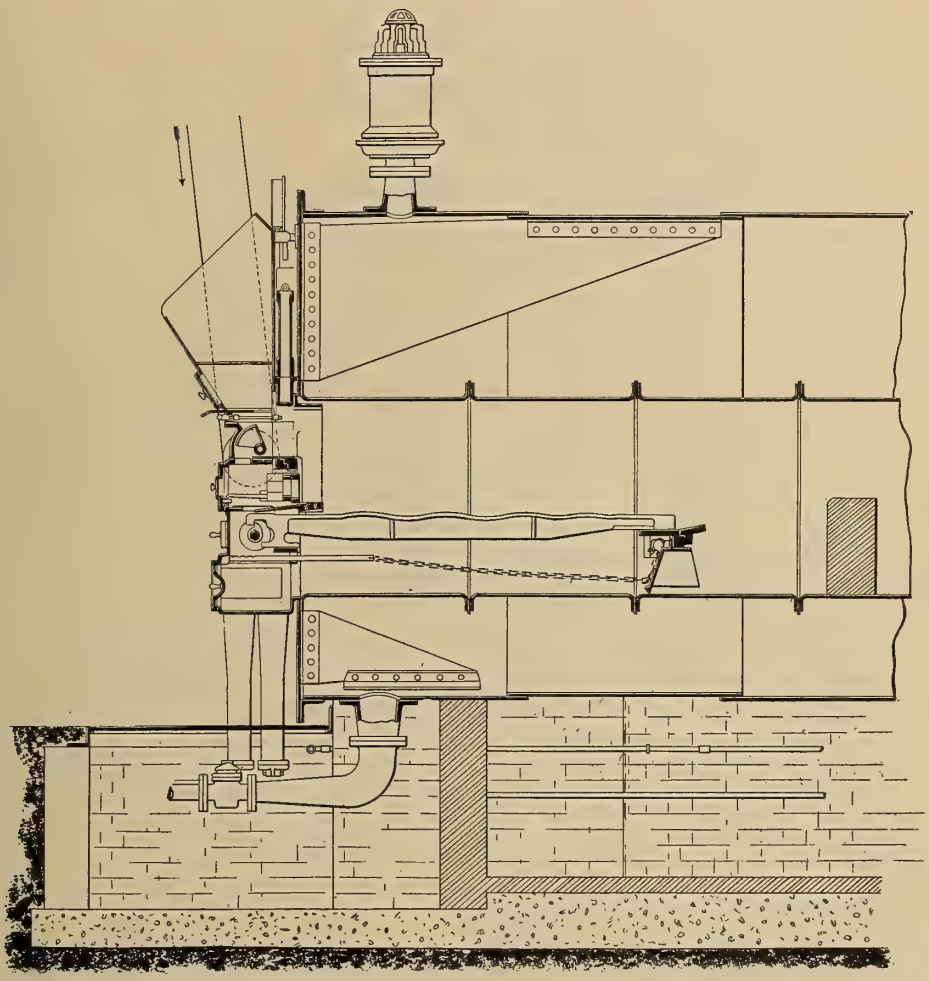
FOSTER SUPERHEATERS AS ARRANGED IN TWENTY 300 H. P. BABCOCK & WILCOX BOILERS IN WASHINGTON NAVY YARD. POWER SPECIALTY COMPANY, NEW YORK



MELDRUM "KOKER" STOKER, MELDRUM BROS., LTD., MANCHESTER

as closely as possible into contact with the gases and fuel in the furnace. The rapid emission of hydrocarbons immediately after each firing necessitates, in addition to the constant supply of air which must be forced through the grate bars for the combustion of the fixed carbon, an auxiliary intermittent supply above the level of the fire, which must be so arranged as to give a maximum supply of air immediately following each charge of fuel, continuing until the combustion of the hydrocarbons is nearly complete, at which point it should gradually diminish as the incandescent state is reached. In some cases a small supplementary supply of air is also necessary at the back of the fire bridge, to further assist the combustion of the hydrocarbon compounds. The manipulation of this fire-bridge supply requires great care, an excess of air naturally resulting in appreciable loss of heat. Much more economical combustion may be effected by mechanical stoking than by the ordinary methods of hand stoking, the introduction of mechanical stokers having, so far, been attended with considerable success, both in efficiency of working and economy of steam production.

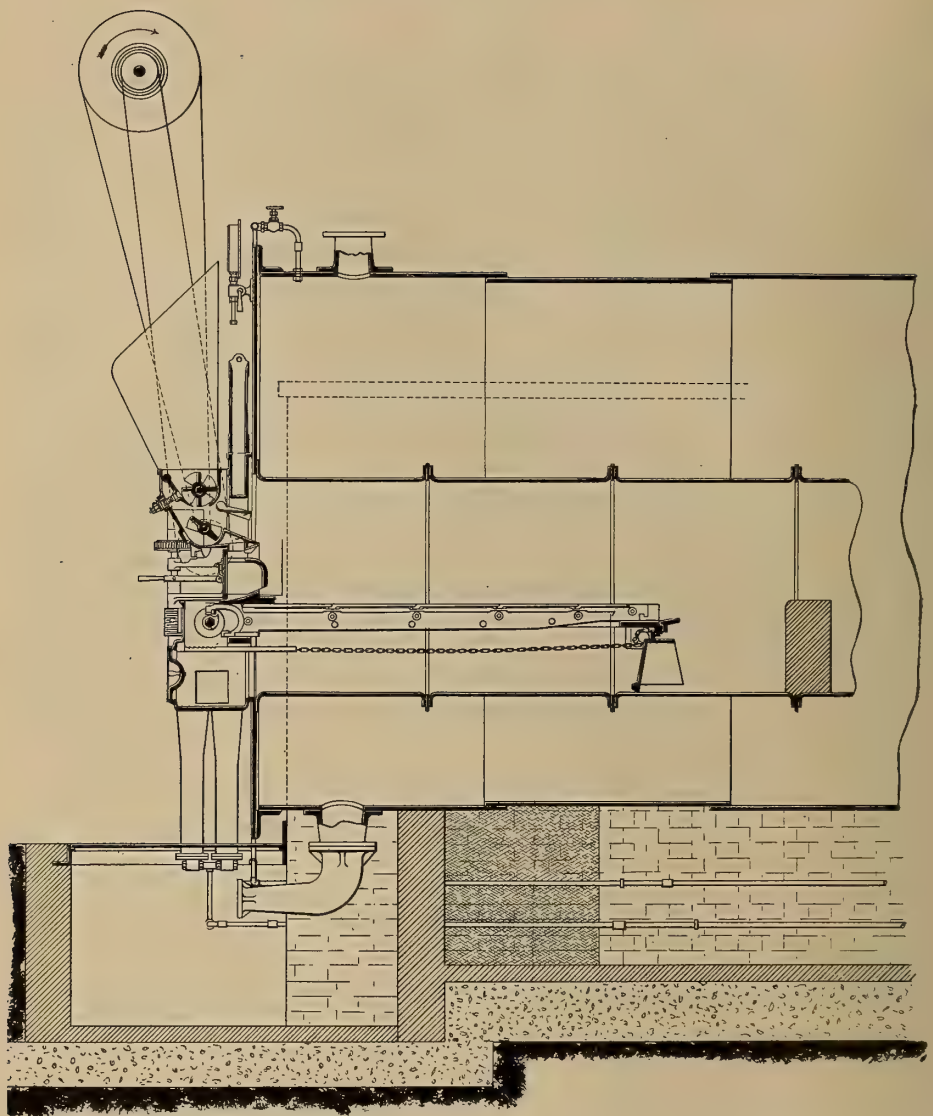
Broadly speaking, mechanical stokers may be divided into two classes: the coking type and the sprinkling type. In the former, which is practically smokeless, the fuel is fed at the front end of the furnace and gradually carried forward by a reciprocating motion of the bars. For forced boilers, or where there is a fluctuating demand for steam, the sprinkling type is more suitable, the fuel in this case being evenly spread in their charges over the whole surface of the fire. The Meldrum "Koker" stoker, which is illustrated in detail, is shown as applied to a Lancashire boiler. The forced draught features of the machine are clearly shown, the vertical position of the blowers having been adopted in order that the air supply may be delivered



MELDRUM "KOKER" STOKER APPLIED TO A LANCASHIRE BOILER

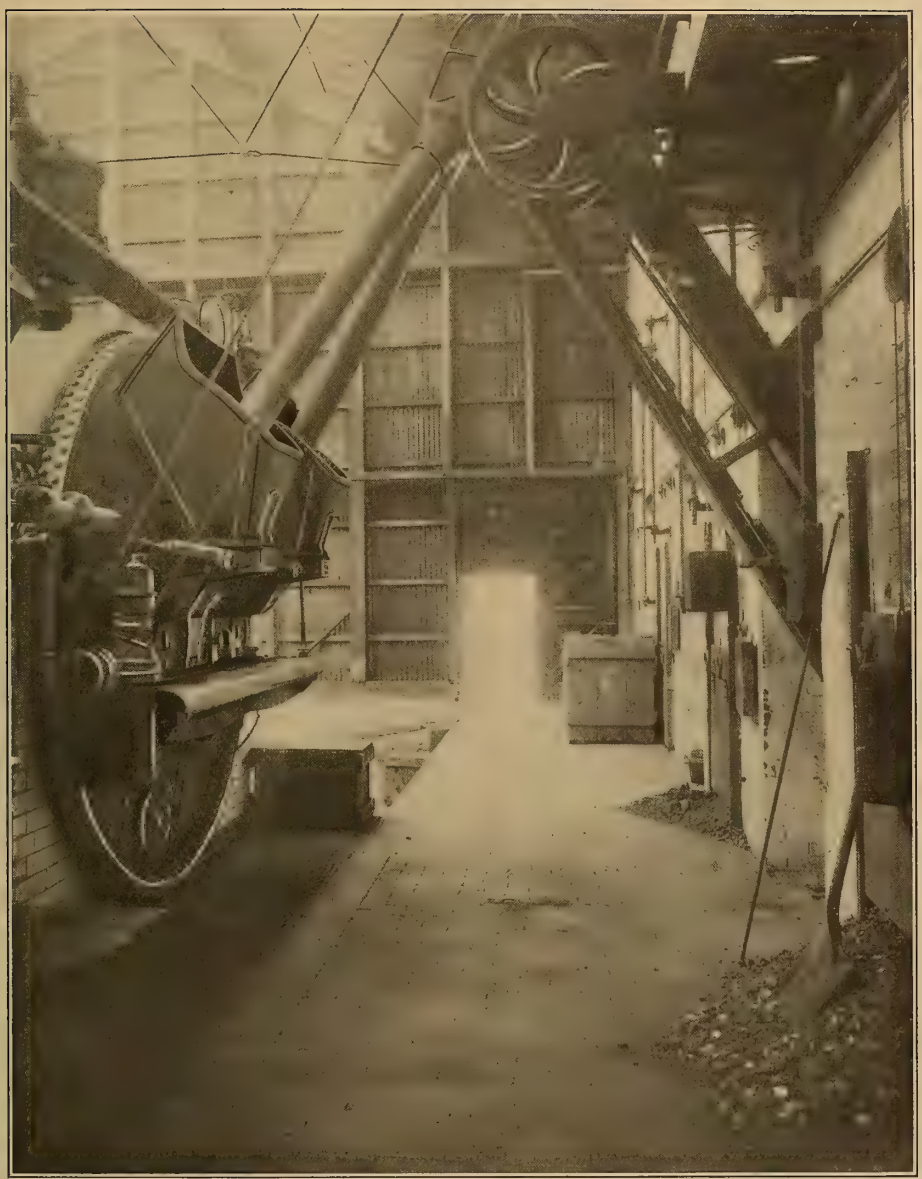
direct to the cams and bar ends, thus enhancing their durability. The fuel falls from the hoppers in front of the sector-shaped rams, which, moving through variable angles according to the required rate of supply, send it forward over the sill until it banks in front of the inner fire door and comes under the influence of the moving grate, the motion of which is effected by a series of cams fitted to a hexagonal shaft, which engage with the bar ends. The bars move forward simultaneously, and return alternately. The coking action takes place when the fuel is banked at the front of the machine, subject to the radiant heat of the more active portion of the grate, the combustion of the evolved gases being effected by air delivered by auxiliary steam jets. In the Meldrum sprinkling stoker the fuel is dropped in measured quantities by means of a slowly revolving four-vaned measure, and then immediately thrown on to the grate by a two-vaned, high-velocity fan, the trajectory being varied by moving deflector plates, thus enabling the fuel to be evenly distributed. All the various details are clearly shown.

A Bennis sprinkling stoker is illus-



MELDRUM SPRINKLING STOKER APPLIED TO A LANCASHIRE BOILER

trated as fitted to a Lancashire boiler, the hoppers being filled by means of a mechanical conveyer in this instance. The coal falls from the hoppers into a cast-iron feeding box, being then mechanically pushed over a ledge formed by the bottom of the box on to a flat plate, from which it is projected on to the fire by an angular shovel, propelled by means of a spring enclosed in a small cylinder, which is shown on the photograph. The return movement of the shovel is effected by means of a cam having four varying lifts, enabling the shovel to give four different lengths of throw, by means of which the whole furnace is evenly stoked. The firebars are given a slight reciprocating movement, being drawn back, one by one, and all sent forward together.



BENNIS'S SPRINKLING STOKER. ED. BENNIS & CO., LTD., BOLTON

Although well-designed mechanical stokers are undoubtedly productive of many advantages, they are not by any means capable of rendering inefficient boilers efficient, and, generally speaking, the application of mechanical stokers to steam boilers ought not to be considered until all other requirements of efficiency have been fulfilled.

(To be concluded in the June issue.)

BREAKAGES OF STEEL RAILS

METHODS OF MANUFACTURE AND INSPECTION TO SECURE A SOUND PRODUCT

By Robert Job

During the past year there has been much attention directed towards the question of railway accidents, and both in Great Britain and in the United States the various causes of such disasters have been the subject of critical investigation. In America especially there have been reported instances of rail breakages which, had they been overlooked, would doubtless have caused serious derailments, and it cannot positively be known to what extent rail failures have contributed to otherwise unexplained accidents. Mr. Job discusses some of the defects in steel rails, and the manner in which they may be discovered by careful inspection and prevented in the course of manufacture, and his paper forms a valuable contribution upon a timely and pressing subject.—THE EDITOR.

THE marked attention which is now directed toward the railroads of the United States renders information pertaining to their operation and management of unusual interest.

Few persons whose thought and training have followed other directions are aware of the wide range of activity and the close study of details which are an essential part of modern railroading if the service is to be safe and efficient.

The question of quality of supplies is of the utmost importance, and a good idea of the care which is used in many directions may be obtained if we consider in a general way the subject of steel rails and briefly show the active effort which is made by the best roads to secure material both durable and safe.

The story of the development of the railroads of the United States during the past three-quarters of a century is one of the most remarkable instances of the modern spirit of aggressiveness and "push." The locomotive has increased in size from almost a toy in the time of Stephenson until to-day it is a common sight to see a monster pulling its load of seventy or eighty cars, each of 100,000 pounds capacity, without being overburdened. From a few yards in length the train has increased to half a mile and over, and the speed has grown from the express rate of ten or fifteen miles per hour until we fly along at the rate of ninety or more miles per hour, and are rather disposed to grumble and call the service slow if the speed runs below sixty miles per hour.

In order to render possible this tremendous development, a revolution has been in progress in the form, character and strength of all parts of the equipment. This is strikingly shown by the fact that if one of the freight cars in common service comparatively few years ago were placed in the centre of one of the heavy trains to-day it would, before long, be crushed like an empty egg shell, even though it withstood the strain at the start.

In keeping with this rapid general change, the growth of the steel rail has of necessity been most marked.

In the '30's of the past century the early engines ran upon thin straps of iron laid upon stringers of wood, or upon short iron rails set on granite blocks, and in some cases the speed was as high as fifteen miles per hour. These types of rails were but makeshifts at best, and soon gave place to other forms, stronger, and better adapted to support the increasing loads. Unfortunately, iron rails were of exceedingly variable quality, and there was, from the start, a demand for a higher grade of material. This was not forthcoming to any great extent, until the discovery, in the year

FIG. 1.—STEEL RAIL AFTER 34 YEARS' SERVICE. JOHN BROWN & CO., 1864

1855, of the Bessemer process for the manufacture of steel, and its adaptation to the rolling of steel rails. The "T" rail in common use in the United States to-day was gradually evolved as a result of many changes, and the production of steel rails by the Bessemer process increased by leaps and bounds up to the present time.

By the year 1860 "T" rails of the weight of 65 pounds per yard were commonly used, and many English rails of the John Brown and Cammell makes were imported, and gave, almost invariably, excellent service. Under continually increasing wheel loads these rails, however, were found too light, and hence there has been a gradual increase in weight to the present practice of 90 to 100 pounds per yard. As girders, these heavier rails have been found much superior to the lighter ones, and the cutting of ties under rail seats was much reduced, while also a far stiffer and smoother-riding track resulted, permitting the drawing of vastly increased loads. It was quickly found, however, that the rate of wear of the heavier rails was out of all proportion to that shown by the lighter rails under the same traffic conditions, and upon careful investigation the causes of the differences became clear. Fig. 1 shows the contour of a 67-pound rail, made by John Brown & Co. in 1864, laid in the same year, and subjected to thirty-four years' continuous service. Fig. 2 shows the granular structure of the steel at the centre of head of the same rail. Fig. 3 shows the granular structure of the steel in a 90-pound rail, centre of head, representing the worst of present practice, and Fig. 4 indicates about the best present practice, with 90-pound sections.

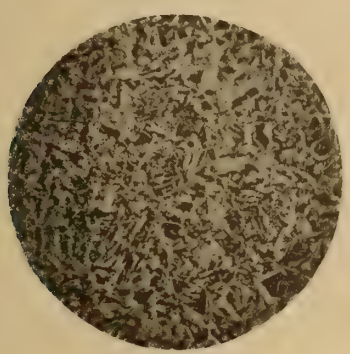


FIG. 2.—STRUCTURE OF HEAD OF RAIL SHOWN IN FIG. 1

FIG. 3.—SECTION OF RAIL HEAD MAGNIFIED 50 DIAMETERS, SHOWING COARSE STRUCTURE

One is impressed at once by the vast difference in the size of the steel crystals. The one form,—the old, fine-grained type,—is slow-wearing and tough, while the coarse structure with the same chemical composition wears rapidly under the same traffic, and tends to brittleness under sudden stress. The cause of the difference is simple enough, for it is merely a consequence of the well-known law that when steel is at a

temperature above its critical point, or above a dull red colour, and is not being subjected to work, the crystals begin to grow in size, and continue growing until the temperature falls below the critical point. When work upon the steel is in progress, as in forging or rolling, this growth is prevented to the depth to which the movement of the metal extends, but as soon as this working is stopped the crystals, as has just been stated, begin to grow, and increase in size until the temperature has fallen below the critical point. In the illustrations which we have seen this law proved to us that metal in the old rails was worked until the

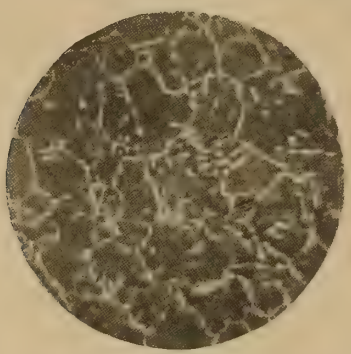


FIG. 4.—STRUCTURE OF MODERN 90-POUND RAIL

temperature had fallen nearly to the critical point, and hence that the crystals had been given very little time to grow. In the case of the more modern rails it is equally clear that working of the steel stopped when the temperature was much above the critical point, thus producing large grains, with resulting lack of tenacity. This defective mill practice is due, in part, to the fact that the modern heavy sections have a comparatively thin flange or base, as compared with the head of the rail, and hence when the temperature of the flange has fallen nearly to the critical point that of the head is far above this point, and the coarse granular form results in the head with consequent low service-value.

In addition to coarseness of granular structure, there are other defects

FIG 5.—POLISHED SECTION OF PIPED RAIL

to which the modern rail is prone and which must be carefully guarded against if safe and efficient service is to result. The worst, probably, of these defects from the standpoint of safety is what is termed the piped rail. This is a rail through which a cavity extends, producing often great brittleness or weakness, and it is this defect which is responsible for the greater part of the accidents due to rail failures. The pipe is caused by the method of manufacture, and is due to the failure of the manufacturer to crop off the ends of the ingots or billets until sound metal

FIG. 6.—A PIPED RAIL. BROKE UNDER FIRST CAR WHEEL

FIG. 7.—A PIPED RAIL

is reached. A characteristic appearance is shown in Fig. 5, and it will be noted that an unwelded seam extends throughout the head and web. Fig. 6 shows a somewhat similar state of affairs, and caused a broken rail when the first car wheel passed over it. Fig. 7 shows the same characteristic appearance, and in Fig. 8 a long cavity extended throughout the length of the rail running almost to the top of the head.

Another serious defect is what is known as porous steel, that is to say, steel which contains a considerable number of blowholes. This defect is also due to defective manufacture, and when the ingot is rolled into rails a large number of unwelded seams are present. When subjected to pressure in track the steel breaks apart at these seams and is crushed or appears to flow over. Fig. 9 shows the result of less than six months' wear upon steel of this character.

We have now considered a few of the most serious defects liable to exist in rails, and in view of the menace to life and limb which their use in track surely brings, the question arises, What means are used by the railroads to detect defective quality when present and bar it from service? What is known as a surface inspection is made by an inspector of the railroad, and by this examination any defects which exist upon

FIG. 8.—PIPE CAVITY IN RAIL HEAD

the surface should be seen and the rails in question rejected. Such an inspection, however, gives no indication of the quality of metal below the immediate surface, and in order to get an indication as to general safety in service the drop test has been devised and is in very general use, especially in Europe. A weight of 2000 pounds is raised to a height of 20 feet, more or less, depending upon the weight of the rail, and is let fall upon a piece of the rail about 6 feet long, placed upon supports about 4 feet apart, the weight striking the rail-butt midway between the supports. If a bad pipe is present, or if the rail is brittle or otherwise unsafe, the sudden blow shatters it. In such case two other rails are tested from the same heat of steel, and, if either of these breaks, all rails from that

FIG. 9.—UNSOUND STEEL IN 90-POUND RAIL

heat are rejected. In the best practice each heat of steel is tested, and the inspector watches carefully to be certain that rails only from the very top of ingots are taken for the test, since such rails are most liable to contain pipes, segregations, or other defects if the practice of the mill has been defective. Fig. 10 illustrates the appearance of one of these segregated rails, broken under the drop test. The carbon contents at the rail centre exceeded one per cent., while at the outside of the head less than one-half of that amount was present. In this case the defective condition was

FIG. 10.—SEGREGATED RAIL, BROKE UNDER DROP TEST.

caused by careless mill practice in the heating furnaces.

In order to maintain the specified composition, analyses are made of each heat of steel by the mill, and these results are checked from time to time at the laboratory of the railroad, and also sections of the rail are taken occasionally for analysis to be certain that the quality is normal.

A tolerably fine granular structure is obtained in the best practice by insisting upon continuous and thorough working until the steel is at as low a temperature as will permit it to pass through the rolls. An approximate gauge to the temperature

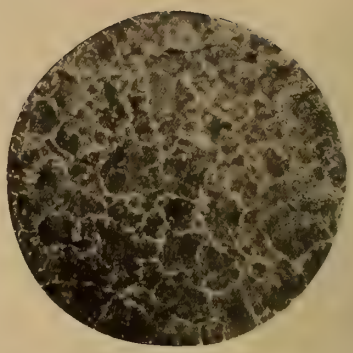


FIG. 11.—SECTION OF TOP OF RAIL HEAD

FIG. 12.—SECTION $\frac{3}{8}$ INCH FROM TOP OF HEAD

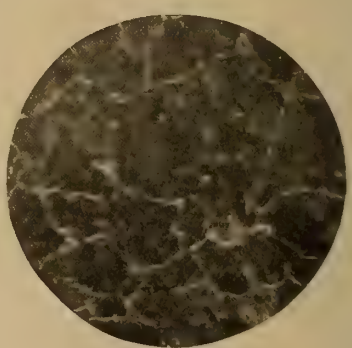


FIG. 13.—SECTION $\frac{3}{4}$ INCH FROM TOP OF HEAD

to which rolling must continue is placed by stipulating that after issuing through the last pass of the rolls the length of the rail shall not decrease more than a definite amount in cooling to the average temperature, say about 70 degrees F. In other words, if the rail after the last pass was at a high temperature the shrink-

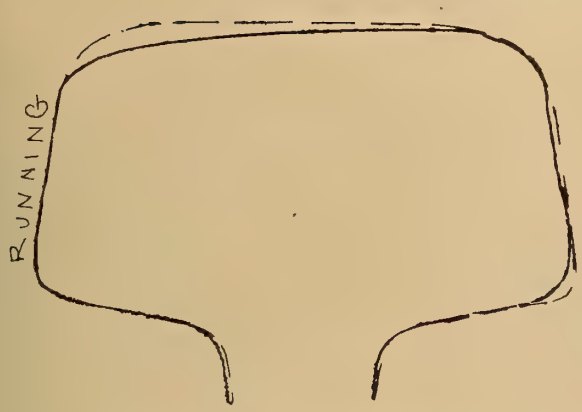


FIG. 14.—CONTOUR OF HARD RAIL AFTER 15 YEARS' SERVICE

age in cooling to the ordinary temperature would considerably exceed the 6-inch limit which is generally stipulated for a 33-foot rail. At some mills the practice is to hold the rail before the last pass, rolling the steel through the other passes at a high temperature and then holding it until it has cooled enough to enable it to meet the shrinkage requirement. If in the final pass of the rolls the steel were thoroughly worked, a fine-grained structure would result throughout the rail; but unfortunately, in this pass there is a reduction of only 5 per cent. or so, and consequently the coarse granular structure which was formed is broken up to a depth of only about one-eighth of an inch, producing a fairly fine structure to only that depth. This is quickly worn away, and the coarse defective structure is then brought into service.

The next three figures show the form of the crystals when the rails are rolled under these conditions,—Fig. 11, at the very top of head of a 90-pound rail; Fig. 12, $\frac{3}{8}$ inch down from the top, and Fig. 13, $\frac{3}{4}$ inch down, or at about the center of head. It will be seen that very coarse structure is present almost immediately below the surface.

From what has been said, it will, I think, be evident that wide variation in quality exists in rails. The poorer ones may last in track for a few days only, and may be the cause of serious disaster, while the best ones, as, for instance, in the older quality, may endure traffic for a quarter of a century or more. The present price of rails in the United States is $28 per ton, and as a single 33-foot rail, 90-pound, section weighs 990 pounds, and as a single railroad system may consist of thousands of miles of track, it will be clear that the duration of the service rendered by the rails is of vast financial importance in the mere first cost, while also a single defective rail may, and sometimes does, cause hundreds of thousands of dollars' worth of damage, not to mention frequently resulting loss of life. Consequently when the rails have been carefully tested and finally accepted, the watchfulness of the railroad may be said to have but just begun, since as soon as laid in track close attention is given to their behaviour by track-walkers, supervisors, division engineers, and, in fact, even

FIG. 15.—CONTOUR OF SOFT RAIL AFTER 15 YEARS' SERVICE

by the management. The testing engineer or chemist is anxious to know how the service of the rails compares with the method of rolling, composition, and general structure of the steel, and makes measurements of the contour of the rails to determine the rate of loss by wear under a given tonnage. Fig. 14 shows one of these contours taken from a 90-pound rail in track after fifteen years' service, and Fig. 15 indicates a contour upon an adjoining rail of the same weight under the same conditions. The much greater rate of wear shown in Fig. 15 is due to the fact that the carbon contents of the latter are much lower than in the former, and the softer steel naturally has ground away the more rapidly.

FIG. 16.—UNSOUND STEEL RAIL, 90-POUND, AFTER SIX MONTHS' SERVICE

The chemist naturally also obtains full information concerning any rails which have fractured or which have failed in service in any respect, in order to obtain replacement from the mill if the failure was due to any defect of manufacture. The best arranged roads also have their tracks connected electrically, and thus, in event of a rail fracturing through any cause, the circuit is broken, and the signals are set automatically in the preceding blocks against oncoming trains.

FIG. 17.—HEAD OF 90-POUND RAIL, SHOWING BURNED STEEL

A short description of the method used to determine the cause of a rail failure may be of interest. In some cases, as, for example, when a bad pipe is present, the cause is evident at a glance. In other cases the prime cause may not be clear. An instance will point our meaning. A number of rails had mashed down in track after a few months' wear, and the mill refused to make replacement, claiming that the difficulty was due to the hard conditions of service. In order to determine the matter, we took a representative section from one of the rails, polished the surface and etched for a few seconds with a solution of iodine. The characteristic appearance shown in Fig. 16 was obtained, proving that the steel was so seriously contaminated with oxides and slag that

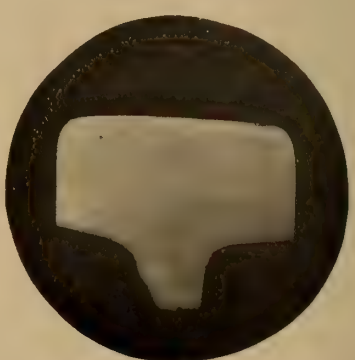


FIG. 18.—HEAD OF 90-POUND RAIL ETCHED WITH IODINE. THIS IS GOOD CLEAN STEEL AND STOOD 14 BLOWS UNDER DROP TEST

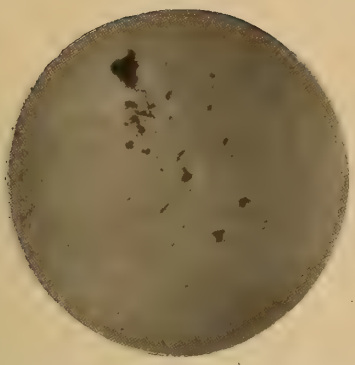


FIG. 19.—POLISHED SECTION MAGNIFIED 50 DIAMETERS, SHOWING UNSOUND STEEL

little tenacity could be expected, and the wonder was that the rail had held together even as well as had been the case. With this evidence in hand the mill made proper replacement without further question.

In some cases the condition of the rails adjacent in track may give some indication as to the cause of failure. In one location where a considerable number of rails had failed, it was

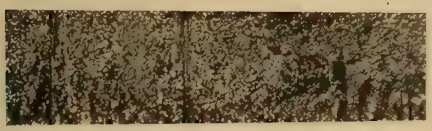


FIG. 20.—SEAM LINES IN UNSOUND STEEL

found that both bad and good rails, from the same rolling, were in the same line of track adjoining one another and under precisely the same traffic conditions. A number of each type were removed and investigated. Analysis gave no clew, but upon light etching of the polished surfaces, it was found that in every case in which failure had occurred the steel was unsound, as shown in Fig. 17, whereas in every case in which normal results had been obtained the steel was almost perfectly free from this defect of unsoundness,—as in Fig. 18. We next examined the polished surface of the unsound steel under the microscope, and found that large numbers of holes and of oxide spots were present, as shown in Fig. 19, and, in order to get the condition more clearly, we fractured the head of the rail along its length, and found that a large number of seam lines were present, as indicated in Fig. 20. In service the heavy wheel loads naturally forced the steel apart at these unwelded seams and thus caused the

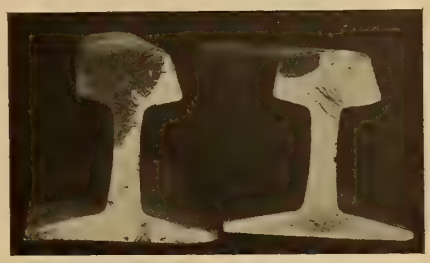


FIG. 21.—STEEL RAILS FRACTURED BY OVERLOADING

rail to crush. In the light of this evidence the true cause of the service failure was evident, and suitable action was taken by the mill in question.

Still another instance may be of interest as illustrating the influence of modern conditions upon the maintenance of track. We have seen how the weight of rails and of equipment has increased to an extent almost undreampt of a comparatively few years ago, and we naturally wonder what influences heavy equipment, combined with rapid speed, have upon the lighter sections of rails. In such a case the result is readily seen, for if the rails are too light they do not have the necessary strength as girders,

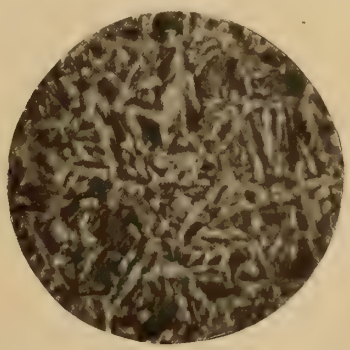


FIG. 22.—COARSE STRUCTURE PRODUCED BY HIGH TEMPERATURE ROLLING

FIG. 23.—FINE STRUCTURE OF ANNEALED RAIL

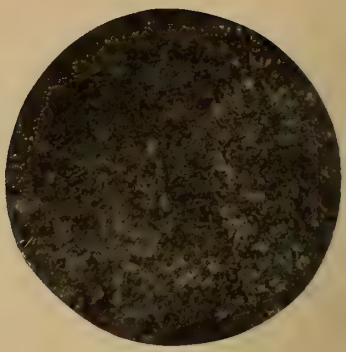


FIG 24.—NICKEL STEEL RAIL

and the section men have great difficulty in keeping up the rail-joints. Also the track assumes a wavy appearance, which may increase very largely the tractive force required to pull a given load. As each heavy wheel rolls over and beyond each tie, the light rail is bent, or in other words, strained beyond its elastic limit; and, as is well known under these conditions of alternating stresses, only a certain time elapses before a hair-crack begins to develop at the surface of the metal. This increases in depth, little by little, until the remaining steel is insufficient to support the loads, and final fracture then occurs, and a wreck is liable to result. The appearance of a rail fractured from this cause is characteristic, and is shown in Fig. 21, which indicates the condition of a 79-pound rail fractured at two places. In each instance the crack began at the corner of the head, upon the running edge, and worked its way downward until nearly half the metal in the rail had been fractured.

In some cases the failure may be due simply to an abnormally rapid rate of wear, or perhaps to extreme brittleness, and in such cases the analysis may show clearly the whole cause of the difficulty, or it may also be necessary to develop the crystalline structure in order to determine whether the mill practice was defective as to rolling temperature. Fig. 22 is an illustration of this class, and shows a very coarse structure produced by high-temperature rolling, with resulting brittleness, while Fig. 23, in contrast, shows the fine and tough structure of an annealed rail. Fig. 24 shows the characteristic appearance of a nickel steel rail, etched and magnified fifty diameters. The small, bright spots represent hard particles of nickel or an alloy high in nickel. Evidently the nickel had not been thoroughly melted and diffused, and, in consequence, the rail would probably have been slivered.

Up to the present time Bessemer steel mainly has been used for rails, but owing to the high proportion of phosphorus present in the principal ores the hardness of the steel cannot be increased sufficiently to meet the requirements of modern heavy traffic, and in consequence the present tendency is decidedly toward the use of open-hearth steel low in phosphorus and sulphur,—the elements which cause brittleness,—and high enough in carbon to give an elastic limit ample to support the loads to which the steel will be subjected. The use of open-hearth steel is not, however, a panacea to all rail ills, for this steel is subject to exactly the same defects as Bessemer steel, consequent upon defective manufacture, and hence the quality of the open-hearth product requires the same careful attention upon the part of the railroad as we have seen is essential in the case of Bessemer steel.

MECHANICAL STOKERS FOR LOCOMOTIVES

By George L. Fowler

IT is interesting to note how very few radical changes there have been made in the designs of American locomotives during the past fifty years. That the locomotive of to-day is a widely different machine from that of 1860 is quite true, but with a few exceptions the changes have been those of modifications of the form and dimensions of details rather than the introduction of an improvement that has marked an epoch in its development. Such changes have occurred about once in ten or twelve years, and have served as a basis for the minor ones that have followed. Among the most important of the things that have been done in locomotive development is the widening of the firebox, that was accomplished by Mr. Theo. N. Ely, in 1882, when he was superintendent of motive power of the Pennsylvania Railroad at Altoona. Previous to that time it had been the universal practice, on bituminous coal-burning locomotives, to use a deep and narrow firebox set between the frames and between the axles of the driving wheels. When the necessary allowances had been made for the thickness of the frames, the width of the water legs and the clearances for eccentrics and driving boxes, the grate area obtained was not more than about 18 square feet.

In the "Class K" locomotive, Mr. Ely raised the boiler to a height that startled the railroad world, and placed the foundation ring of the firebox on top of the frames, by which he was able to add a full 8 inches to the width, while the length was limited only by the ability of the fireman to handle the fuel. With this arrangement the grate area could be increased to about 33 square feet, with a corresponding increase in the power of the engine. This great enlargement did not take place at once, but we grew up to it gradually. When the upper limits, made possible by Mr. Ely's improvement, had been reached, a still further widening was accomplished by an improvement introduced by the Baldwin Locomotive Works in their Columbian locomotive, shown at the Chicago Exposition of 1893. In this engine the firebox was set back of the driving wheel, and, instead of being placed between them, as in the Class K, was considerably widened and carried by a single pair of trailing wheels. This set no limit to the size of the grate beyond the clearances of the track and the ability of the fireman to properly place the coal. The same results are also obtained by the combination of the two improvements, and placing the wide firebox above the drivers.

The result of these changes has been that to-day grate areas of 55 square feet are used on consolidation locomotives in regular road service, instead of the 18 square feet which was the maximum thirty years ago; while in some Mallet compound engines recently built a grate area of 78 square feet is used, or nearly five times that of earlier engines.

Now, American railroads are not coddling their locomotives, but have a reputation for forcing them to the utmost limits of their capacity, and to do this the maximum amount of coal is burned on the grates, and this rises to more than 150 pounds per square foot per hour. Sometimes it goes up to as much as 250 pounds, and 175 pounds can be taken as quite common practice. This means that instead of shoveling a little more than one and a half tons an hour, as in 1880, the fireman must now handle between four and five tons on an ordinary road engine. But this fireman is no bigger or stronger than his predecessor of twenty-five years ago, and the firing of this large quantity of coal on the floor of a moving vehicle is a serious tax on his endurance, and results in a marked falling off in efficiency before the end of a division is reached. In some cases the men work in relays, but this is inconvenient and expensive, and so there is an urgent demand for a mechanical stoker.

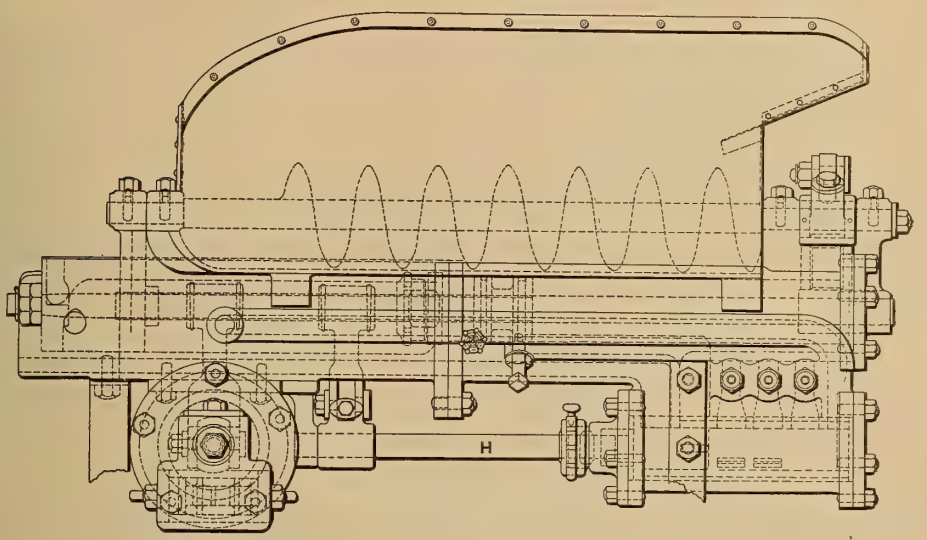
It is needless to say that the mechanical and inventive genius of the country has been at work upon the problem, and innumerable schemes have been suggested. The solution, however, is not an easy one of accomplishment. The actual requirements are that the device shall be very compact, so as to be placed within the limited space available in the cab and in front of the coal boards on the tender, and still leave space for the free movement of the engine crew. It must be readily detached and put out of service, so that, in case of its failure, hand firing may be resorted to at once, without disabling the engine or delaying the train. It must be free from complications of construction, so that it may be easily manipulated and repaired by the men usually available for this class of work. It must be of substantial construction, so as to withstand rough usage without failure. It must permit of easy access to the fire for cleaning and inspection. It must be designed so as not to impede the boiler makers in gaining access to the firebox. It must effect an even distribution of coal over the whole surface of the grate, and be able to handle all grades from lump to dust. It must do its work so as to maintain the working pressure through all variations of service, regardless of the demands that may be made upon the boiler, and do it with an evaporative efficiency of the coal at least equal to hand firing.

It will be acknowledged that these requirements are rather severe and not easily met, but they are the absolute essentials, to which other desirable qualities might be added, such as an automatic operation, coal conveyors from tender to engine, and the like, but these are not insisted on at present.

Of course, a machine that will fulfill these demands cannot be designed in an office. It must be worked out to the best of the ability of the engineer in charge, then built and tried on a dummy firebox in order to make sure of the distribution of the coal, after which it may be applied to a locomotive in service.

Up to the present time but two stokers have been tried with any measure of success. These are the Kincaid, afterwards known as the Victor, and the Hayden. In both of these there has been an entire cutting loose from the precedents of stokers used in stationary work: a change necessitated by the greatly increased rate of combustion in the locomotive boiler, as well as that absence of space available for hoppers, conveyors and other appurtenances that obtains in the stationary plant where 50 pounds of coal per square foot of grate area is rapid firing.

These two mechanical stokers are not yet out of the experimental stage, and have not been applied at large. The railroads are simply interested spectators, watching and waiting. The work of development has been going on for a number of years,

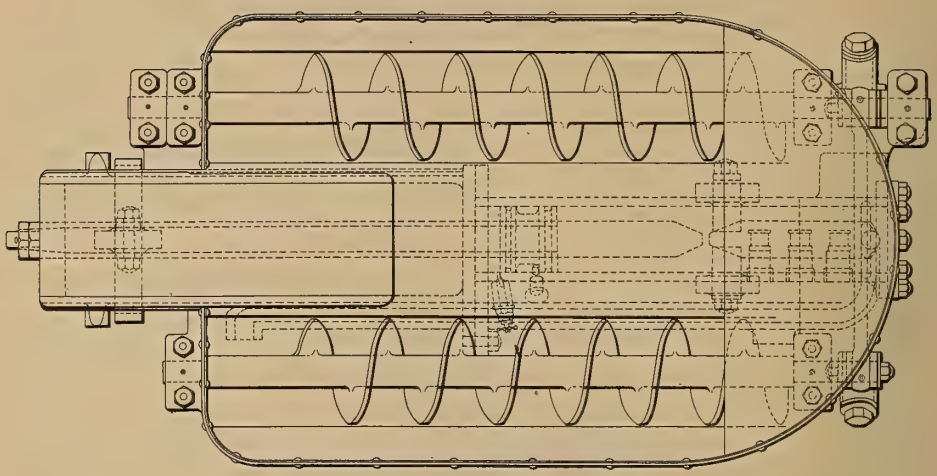


VICTOR MECHANICAL STOKER. SIDE ELEVATION

and in 1905 the American Railway Master Mechanics' Association appointed a standing committee whose duty it is to report the progress made in mechanical stokers to the convention from year to year, thus showing that an immediate solution of the problem is not expected. At the convention held in June last, this committee reported that data received from several sources had been considered, but these were not "sufficiently conclusive to submit to the association at the present time."

In attempting to do the work of the firemen, the designers of the two stokers referred to have been working along somewhat different lines. The Victor stoker distributes the coal over the grate under the impulse of a rapidly moving piston. It consists of a hopper, in the bottom of which is a steam cylinder with a piston moving to and fro driving a stoking head which propels the coal into the firebox at varying velocities, so that it is evenly distributed over the whole surface of the grate. The valve mechanism for this operating cylinder is driven by a special engine that also drives the feed worms whereby the coal is carried forward to the front of the stoking head, by which it is thrown into the firebox, as already stated. These worms or conveyor screws lie at the bottom of the hopper at each side of and a little above the operating cylinder.

The conveying screws, as well as the valve for the operating cylinder, are moved by ratchets that are driven by a small steam cylinder *A* set across the apparatus, and which is a modification of the Westinghouse air pump engine. The movement of the piston of this cylinder carries the arm *B* that turns the worm ratchets, and also the arm *D* that is keyed to the shaft *C*. This arm *D* turns a ratchet on the valve stem *H*, which is fastened to the main valve. This is a hollow plunger valve having three ports located 120 degrees apart, two of which appear in the section. As the valve is rotated, steam is admitted consecutively to the plug valves, 1, 2 and 3. These are adjustable, and are set to wire draw the steam to a greater or less extent, by which any predetermined amount may be admitted to the plunger cylinder *K*. It is evident that the wider the opening in these valves, the greater the amount of



PLAN OF VICTOR MECHANICAL STOKER

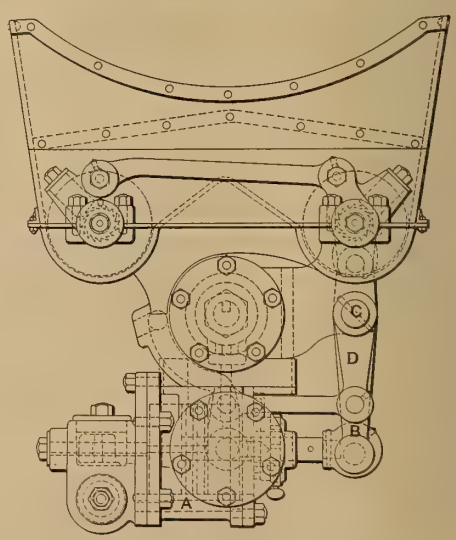
steam passed, and the more rapid and violent will be the forward movement of the plunger. By this means the force with which the coal is thrown into the firebox is regulated. Ordinarily these valves are so adjusted that on one stroke the movement will be of such a speed as to throw the fuel to the front of the grate; at the second, it throws it over the middle section, and at the third it drops close to the back. It is to be understood that steam is admitted to the interior of the trunk valve from the live steam pipe.

The coal enters the firebox over a deflector plate that is subjected to the full effects of the fire, with such cooling as may come to it from the inrush of air when the plunger is drawn back for a fresh supply of fuel. These plates are of cast iron, and will last for about a month and a half of continuous service. It serves to effect a proper scattering of the fuel.

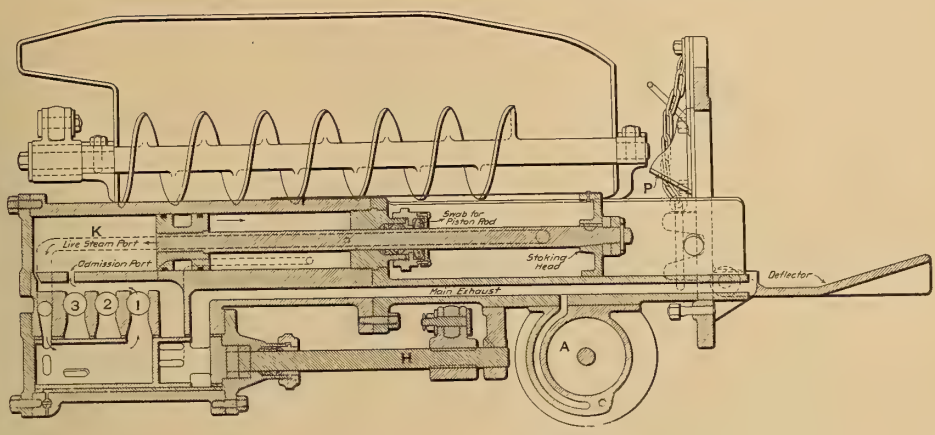
As the plunger is drawn back, a space is left between its front face and the end of the hopper through which air rushes into the firebox and into which the coal for the next charge is drawn by the screws. All fine pieces readily pass through this opening, while lumps raise the swinging door *P*. If the lump is too large to enter through this, it is invariably broken by the force of the blow delivered by the plunger.

The rôle played by the fireman in the manipulation of this stoker is to shovel coal into the hopper from the tender and regulate its speed of operation. The mechanism is of so simple a character that it is readily mastered by any man of ordinary intelligence.

In practice it has been found to be capable of maintaining a constant steam pressure up to working limits on heavy locomotives hauling fast



VICTOR MECHANICAL STOKER. END VIEW



VICTOR MECHANICAL STOKER LONGITUDINAL SECTION

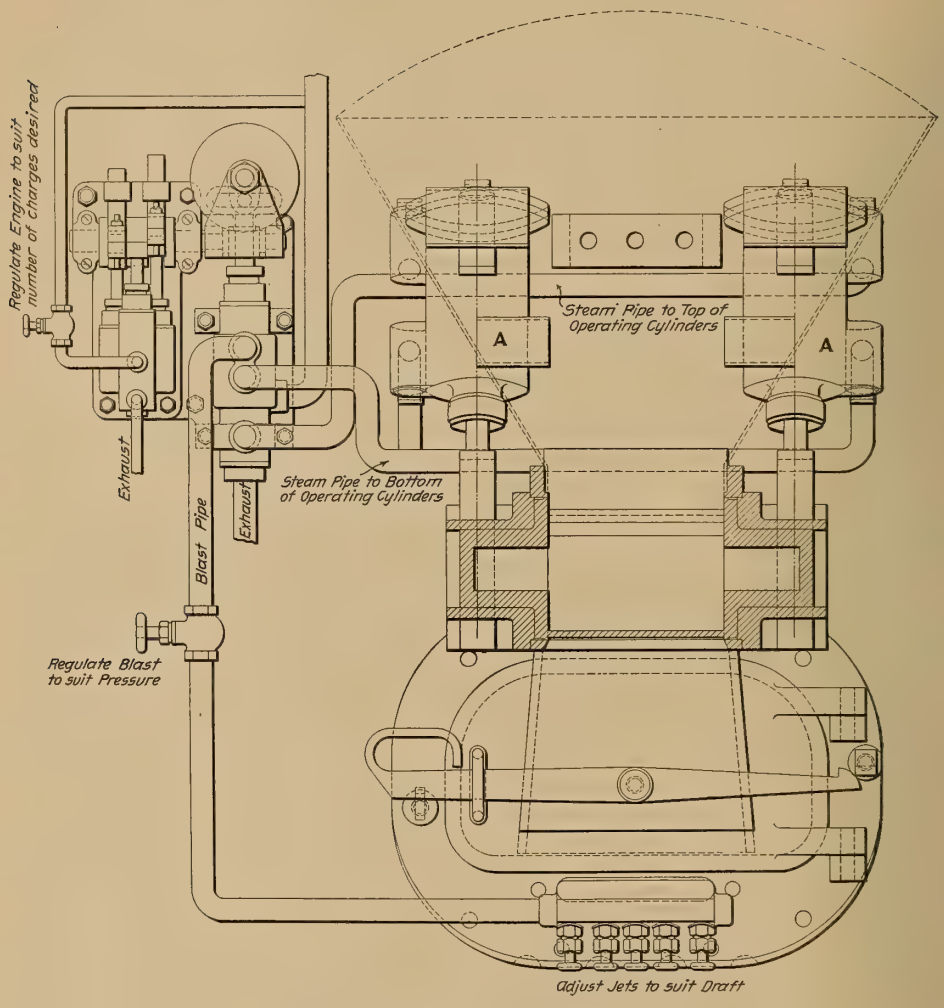
express trains. Although the fireman is required to shovel all of the coal used into the hopper, this involves much less labour than putting the same amount into the firebox. Not only is the actual exertion less because of the slight lift and the absence of the necessity of throwing, as well as the fact that the door need not be opened, so that the man is not exposed to the direct rays of the fire. He stands back away from the boiler and works where it is comparatively cool.

It is not claimed that the stoker effects any saving of coal, nor that it prevents the formation of smoke. Indeed, the coal consumption is well up to that of hand firing, and the smoke issues from the stack continuously. It varies in density according to the position of the plunger, and when the latter is forward, closing the opening into the firebox, it is darkest. When the plunger is back to receive a fresh supply and there is an inrush of air, providing oxygen for the combustion of the hydrocarbon gases, the smoke thins away very perceptibly, so that the strokes of the plunger, which average about twenty to the minute, can be readily counted by an observer alongside the track. This has led to the suggestion to use air flues expanded in the back sheets by which a continuous supply of oxygen may be furnished that will suffice for the combustion of these gases and thus lessen the production of smoke.

For the relief of the fireman from the greater and more trying portions of his work and the maintenance of the steam pressure this stoker is efficient. But when applied to existing locomotives with fire doors of the ordinary size, it so blocks the opening that the raking and cleaning of the fire on the road is rendered very difficult. It also occupies a good deal of floor space, which is not always available on engines whose boilers reach to the rear of the cabs; and finally, if it breaks down, the time required to remove it and put the engine in condition to proceed with hand firing is somewhat excessive and involves a serious delay to the train. There are other minor defects that are probably in process of elimination, but those mentioned are the more serious.

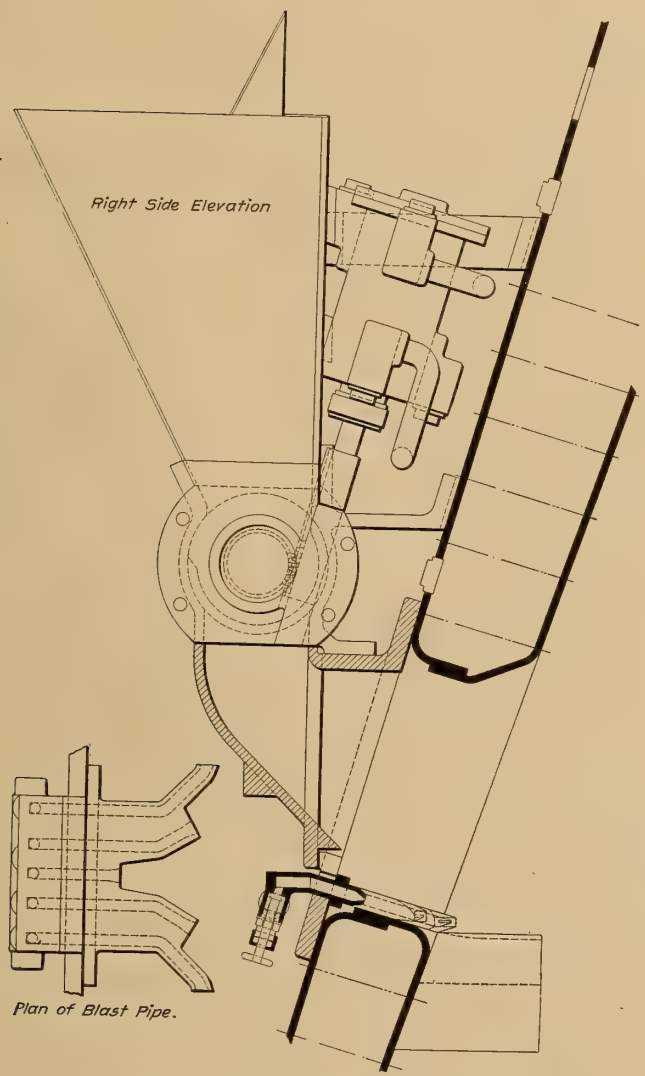
It is probable, too, that these could be in part removed, if an engine with its boiler, cab and tender were to be designed for the especial use of the stoker; but this has not yet been done, and the apparatus must be adapted for use on existing engines.

The Hayden stoker differs essentially from the one that has just been described. It performs all of



HAYDEN MECHANICAL STOKER. FRONT ELEVATION

the functions of taking the coal from the tender, dividing it into small portions and distributing it in the firebox. For this there is, first, a heavy grating placed just in front of the coal gates on the floor of the tender beneath which the horizontal section of the coal conveyor is made to travel. Coal dropping through the grating is taken by the conveyor and carried up on one side and thence through an overhead passage back to the centre, where it drops into the tube of a screw conveyor, by which it is carried forward to a point just back of the boiler head, where it drops into a hopper. The bottom of this hopper is closed by a valve which is capable of turning through a half revolution and receiving a charge of coal when its opening is uppermost. The coal is then held in the shell of which the valve is formed. The half turn drops the coal on a shelf just at the bottom of the door at the rear of the firebox, whence it is blown by jets of steam to various parts of the firebox with an even distribution. The rate of feeding can be varied to suit the exigencies of the work that the locomotive has to do and the quality and



HAYDEN MECHANICAL STOKER. SIDE ELEVATION

character of the coal that is to be used.

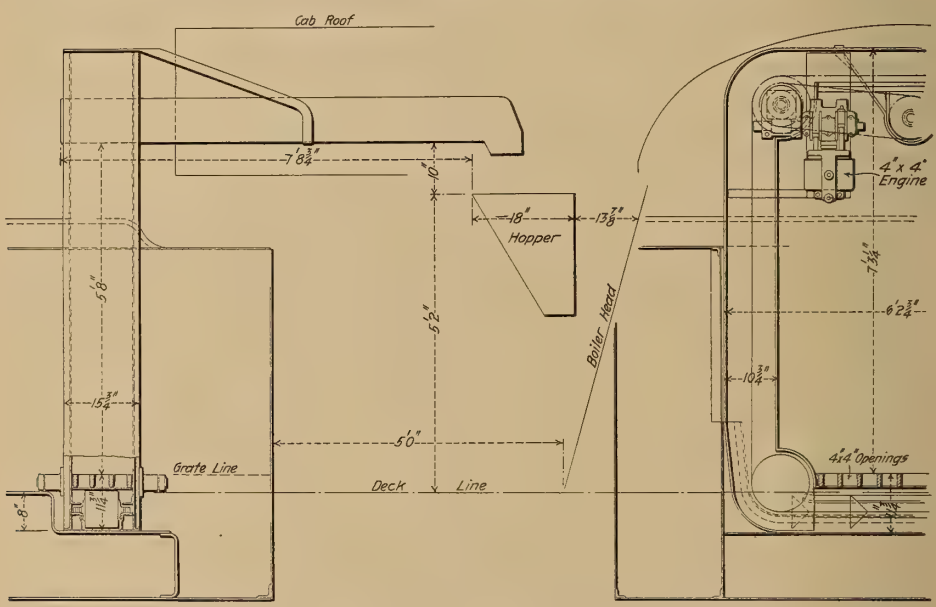
The general arrangement of the device is shown in the side and end elevations, by which the course of the coal from the grates on the tender to the hopper on the boiler head will be clearly understood.

The charging valve is located beneath the hopper. It is in the form of a hollow shell, and will hold about 12 pounds. The coal drops into it when the opening is uppermost. It turns on trunnions that are centered in the main casting and which are fitted with spur gears at their outer ends. These gears mesh with a couple of racks that are directly connected to the piston rods coming from the two operating cylinders *A A* placed above the door and partially back of the hopper on either side. As the pistons of these two cylinders move up and down, the motion is communicated to the rack and by them to the valve, which is turned

through a half revolution at each full stroke. The valve for these cylinders is driven by a special engine bolted to the boiler head. The maximum rate of feed used upon a heavy consolidation locomotive is about fourteen strokes per minute. The valve being driven by a worm necessitates that the small engine shall run at about 1000 revolutions per minute.

With the coal delivered from the valve there yet remains the important function of its proper distribution over the grates. This is done by means of the five-jet nozzles shown in the plan of the blast pipe. Steam is admitted to all of these nozzles through a pipe leading from the operating valve, and in which there is a valve, so that the flow, as a whole, can be controlled. Each nozzle is further provided with an adjusting valve by which the intensity of the individual jet can be regulated to accord with the size of the firebox, the intensity of the draught and the quality of the coal used. The two at the outside turn almost at right angles and serve to deliver in the back corners of the firebox; the intermediate jets throw the coal along the sides and into the front corners, while the one in the center throws it straight ahead.

The requirements that the fire shall be easy of access for cleaning and hand firing be at once resumed in case of a disablement of the mechanism is met in the design of the fire door. This is so arranged that it can be opened at any time, as the hopper and valve are set above it.



HAYDEN MECHANICAL STOKER. SIDE AND END ELEVATIONS, SHOWING ARRANGEMENT OF CONVEYOR

It carries a chute on the back into which the coal is delivered from the valve, and, beyond this, simply takes the place of the ordinary door and can be used as such at any time.

As a labour saver this stoker is somewhat ahead of the Victor. There is really no shoveling to be done at all. The coal flows down from the gates to the conveyor by gravity, and the principal duty of the fireman is to prevent it coming down too fast when the tender is full. Later it has to be drawn forward as the supply is diminished back of the angle of flow, but there is no lifting to be done. Also if there are any lumps too long to pass through the open-

ing of the conveyor grate they have to be broken. But the whole of the work is so light that a fresh man, unaccustomed to manual labour, could readily do the firing on a heavy consolidation locomotive hauling sixty-five cars over a division a hundred miles in length, and hold the working pressure of the steam without trouble.

As a smoke preventer, the Hayden stoker ranks with the other in that it does not do it. There is a continuous stream of smoke issuing from the stack at all times. It is probable, however, that a portion of the gases now escaping in this form could be burned by the admission of more air above the fire, which is a matter for experiment.

In coal consumption there is nothing to show that there is any saving over hand firing. There is no reason, though, why it should not effect a very material saving, provided it is properly handled.

In regard to this, it has been a fundamental idea in instructions to firemen for years that they should throw small quantities, such as one shovelful, into the fire at a time, and the men who have followed these directions have been the most successful and economical in the use of coal. The stokers do this, and do it systematically at short, regular intervals, thus following ideal conditions for the work, and, if the air supply above and below the grates is properly regulated, there is no reason why a noticeable saving in coal should not be made as compared with the best of hand work.

But this cannot be done by a man who is not skilled in his work. Where trials have been made with mechanical stokers, there has been a feeling on the part of some of the men that they would make it possible to use a lower grade and less skilled and consequently cheaper class of fireman, and so there has been some evidence of hostility to the new device. Nothing could be more at variance with the facts. It is quite true that the man does not have to work as hard with his muscles, but he will be kept busy with hand and brain over every inch of his run. The mechanism requires constant attention and adjusting in order that the coal supply may be varied with the demand of the engine; that the dampers and other sources of air supply may be properly set; that the steam is held at a constant point, and that the most efficient rate of combustion is maintained. In fact, instead of making it possible to use a cheaper grade of fireman, the best that can be obtained will be none too good, and the fact that such a man has to use his brain and that his muscles are relieved from the drudgery now involved in firing heavy locomotives, will make it possible to secure men better fitted for the work than many who are now employed and whose sole qualification seems to lie in the fact that they are the possessors of large and hardened biceps.

As already stated, railroad officials are waiting with the greatest interest for the development of a mechanical stoker that will meet the requirements that have been set forth as a means of relief for the tasks imposed in the firing of the large locomotives that are now so extensively used.

PETROL TRACTORS

By J. F. Gairns

One of the departments of automobile design to which comparatively little attention has been given, is that of hauling one or more trailers for industrial purposes. Nearly all the work which has been done in this line has been in connection with steam-power machines, and the gasoline automobile has been almost ignored. In France the Scotte train is well known, and more recently the ingenious system of the late Col. Renard has been designed, and while the latter has been used in connection with a petrol tractor the former used a steam machine. In the United States little or nothing has been attempted in this direction, and hence the paper by Mr. Gairns, giving, as it does, the best English practice in the use of gasoline automobile traction, may be considered as representing the present state of the art in what should be an important department of automobile engineering.—The Editor.

ALTHOUGH petrol engines (including, as a general term, petrol, paraffine, benzine, alcohol, gasoline, and like explosion engines) are now very extensively employed for heavy industrial motor road vehicles in all parts of the world, it is somewhat strange that their application in connection with "tractors," i. e., locomotive vehicles whose sole function is that of hauling non-locomotive vehicles, is as yet very limited indeed, more especially as steam "tractors" (generally in the form of small traction engines, but occasionally corresponding with commercial vehicles minus the load carrying space) are in very general use, especially in Great Britain.

At first sight, it may appear that this is only reasonable and to be expected, for a petrol operated commercial vehicle may require little space for the engine and supply tanks, etc., and the utilization of most of the platform space available for load carrying purposes is, therefore, an obvious practice. There is, however, a large field of work for which load carrying vehicles are unsuited, and in some cases the employment of an unloaded commercial vehicle for hauling a non-motor vehicle is not convenient or really practicable.

For example, in the case of a removal firm whose work consists usually in conveying goods in pantechnicons, vans, and like vehicles, the load is usually a heavy and bulky one. If the vehicle itself is to be fitted for self-propulsion, a very powerful engine is required, and the engineering problems involved almost preclude such methods being adopted. The obvious alternative is to haul the pantechnicon by a tractor, and, although an unloaded motor vehicle may be employed in that capacity, its own want of load to enable its power to be properly applied, and the great power required, act as serious deterrents even if it is possible to operate in that manner.

Again, many firms find it more convenient to carry the load on non-motor vehicles (which may be adopted for horse traction on occasions), and this is specially desirable when bulky and inconvenient loads, such as girders, lumber, and machinery, have to be conveyed.

Further, there are restrictions on the weight and power of commercial vehicles, while other considerations also render the employment of a powerful "tractor," carrying large fuel supply and capable of hauling any required load under traction engine conditions, a preferable practice.

Until quite recently, and still generally, steam tractors only have been employed for working in this manner; but in a few instances petrol motive power has been applied for similar purposes, and in the following pages a review of existing Brit-

FIG. 1—MOTOR TRACTOR. JOHN I. THORNYCROFT, LTD., CHISWICK

ish practice in this connection is given.

As regards practice in other countries, the writer is not aware of any instances of a similar or corresponding character.

As will be seen, our subject divides into two sections, (1) tractors designed to meet the conditions above set forth, and (2) tractors designed for application for agricultural purposes. A third section is also included as a development of the preceding, and although in these instances the machines are not intended for hauling other vehicles, their design and characteristics are sufficiently similar to justify consideration in this article.

In a series of articles contributed to these pages by the present writer in 1905 one example of a petrol tractor was described (CASSIER'S MAGAZINE, August, 1905), and this constitutes, to the writer's knowledge, the first application of this character.

As illustrated on that occasion, the tractor was employed hauling a load of barrels on a lorry. The same machine is now illustrated, without load, crossing very uneven ground.

The designers and builders are the well-known firm of Messrs. John I. Thornycroft & Co., Ltd., of Chiswick, near London. In general outline the machine is built to correspond with the usual types of steam "tractors," but that is not an important feature. It is designed for hauling a gross load of up to 6½ English tons on ordinary macadam roads graded up to 1 in 8; but by fixing "spuds" to the wheels, as illustrated, it can extricate itself from soft ground or travel over very rough ground without it being necessary to employ a winding drum, though that is fitted to meet special emergencies.

The engine is of the two-cylinder type (6 inches diameter by 8 inches stroke), developing 25 brake-horse-

FIG. 2.—PETROL TRACTOR. J. B. PETTER & SONS, LTD., YEOVIL

power under normal conditions. The exhaust, after passing through a silencer, is discharged up the chimney, and is considerably diluted by the admixture of air induced by the draught and is rendered very nearly innocuous.

The cylinders are water-jacketed, and the water is circulated by a rotary pump and cooled by a partial

FIG. 3.—AN ELSTOW TRACTOR HAULING A LORRY

evaporation system by means of an air current induced by the discharge of the exhaust up the funnel and supplemented by the draught of the fly-wheel fan.

The gearing runs in oil, and is of the type wherein the wheels are continually in mesh. Three speeds, both forward and reverse, are provided for, and the final transmission is by means of a Renold roller chain to the differential gear on the rear axle. The speeds provided for are $1\frac{1}{2}$, 4, and 8 miles an hour.

Fuel capacity for 60 miles (petrol or ordinary kerosene), but an additional tank for 50 miles can be fitted.

The tractor can be adapted with very little trouble as a portable engine. The tractor is 12 feet 6 inches long, 6 feet 4 inches wide, and 10 feet 2 inches high, and weighs about 3 tons.

So far as the writer is aware, the use of this machine has been very satisfactory, and several other similar tractors have also been supplied.

The remaining examples of petrol tractors are principally of quite recent introductions, mostly in the present year, and they all attracted great attention at the Royal Agricultural Society's show, held in June, 1906, at Derby.

Fig. 2 shows a petrol tractor built by the firm of J. B. Petter & Sons, Ltd., of Nautilus Works, Yeovil, Somerset. In this case the machine is shown hauling a large pantechnicon for furniture removal. It is designed so that it can be easily adapted as a portable engine for driving threshing machines, circular saws, mortar mills and other purposes.

FIG. 4.—AN ELSTOW TRACTOR OPERATING MOWING MACHINES

The following comparison between a machine of this type and a steam tractor, as furnished by the builders, will be of interest:—

(1) Decreased weight of fuel, amounting to only about one-eighth the weight of coal.

(2) Absence of water difficulties, a sufficient quantity being carried for the whole day's run. Thus the great inconvenience and delay of obtaining water every eight or ten miles is obviated.

(3) Absence of attention required

FIG. 5—IVEL AGRICULTURAL MOTOR HAULING A PLOUGH

by a steam engine and boiler makes it quite easy for the oil traction engine to be worked by one man, instead of the two required on a steam tractor. The engine having been once started, works automatically without attention from the driver. The steam tractor, on the other hand, requires the driver's attention to be continually given to such matters as: Stoking of the fire, level of the water in the boiler, steam pressure, water supply, which practically require the whole of one man's attention, besides leading to a great waste of time through stoppage.

It is also claimed to be far less costly in up-keep than a steam tractor, owing to the absence of a boiler, firebox, tubes, gauges, injectors and other appliances peculiar to steam practice.

The engine is a single-cylinder type, with governors controlling both the air and oil supply, the governors being adapted for adjustment by the driver according to the speed of operation. The gearing provides for speeds of 2½ and 5 miles an hour. A winding drum which can be driven by the engine is fitted. An induced draught air cooler is fitted for the jacketing water. The usual fuel provides for a run of ten hours. The tractor may be adapted by changing the wheels for use as a road roller.

The tractor now to be described possesses several unusual features, and it is intended more for hauling agricultural machines than for ordinary road haulage.

Fig. 3 shows one of the Elstow tractors, built by Messrs. H. P. Saunderson & Co., Ltd., of Bedford, employed hauling a load of bricks on a lorry, a portion of the load being also conveyed on a platform fitted to the tractor, and Fig. 4 shows it in use hauling a mowing machine.

These machines are more correctly described as universal motors, for they are capable of being adapted in a semi-combined fashion in various ways, as lorries, for hauling and operating ploughing, mowing, reaping, binding and other agricultural

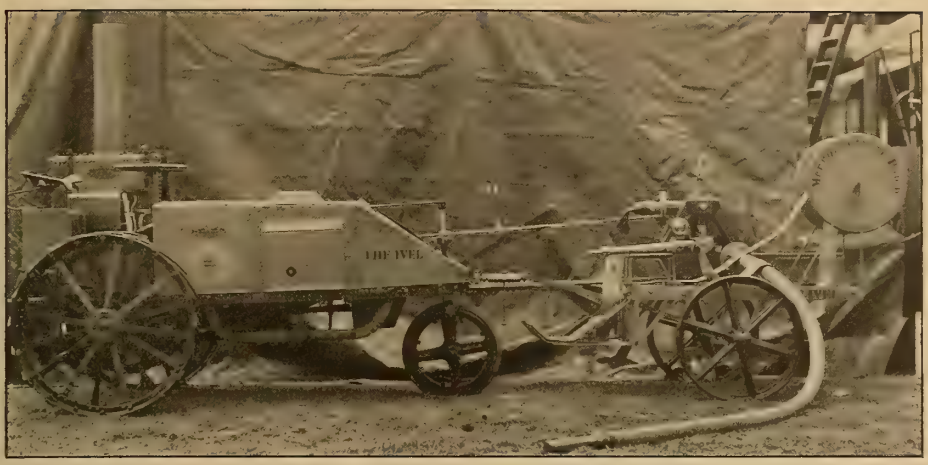


FIG. 6—IVEL AGRICULTURAL MOTOR DRIVING A PUMP

machines, and for operating threshing, chaff-cutting, grinding, sawing and other machinery. In fact, it is intended to do the work of a horse team according to any of the usual methods of operation. The tractor is mounted on three wrought-iron travelling wheels, all of which are adapted for propulsion. The third wheel is driven from the balance gear of the differential shaft, and it will, therefore, be seen that neither of the differential wheels can slip unless the third wheel slips also, excepting when rounding a corner, and then, owing to the track of the third wheel being midway between the other two, the differential action is

FIG. 7—MOTOR ROAD ROLLER. BARFORD & PERKINS, PETERBOROUGH

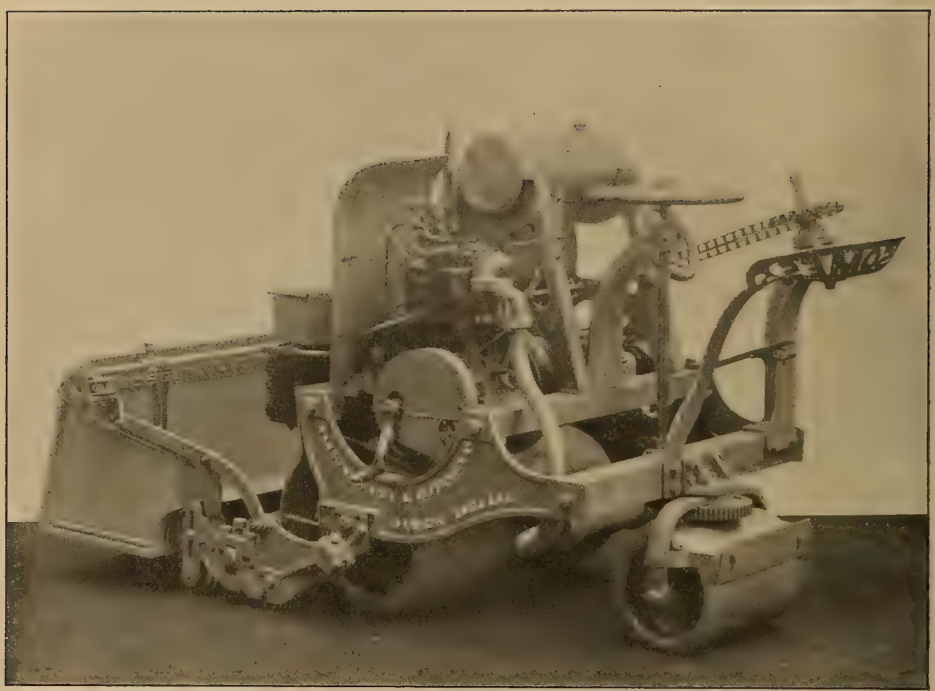


FIG. 8.—MOTOR LAWN MOWER. RANSOMES, SIMS & JEFFERIES, LTD., IPSWICH

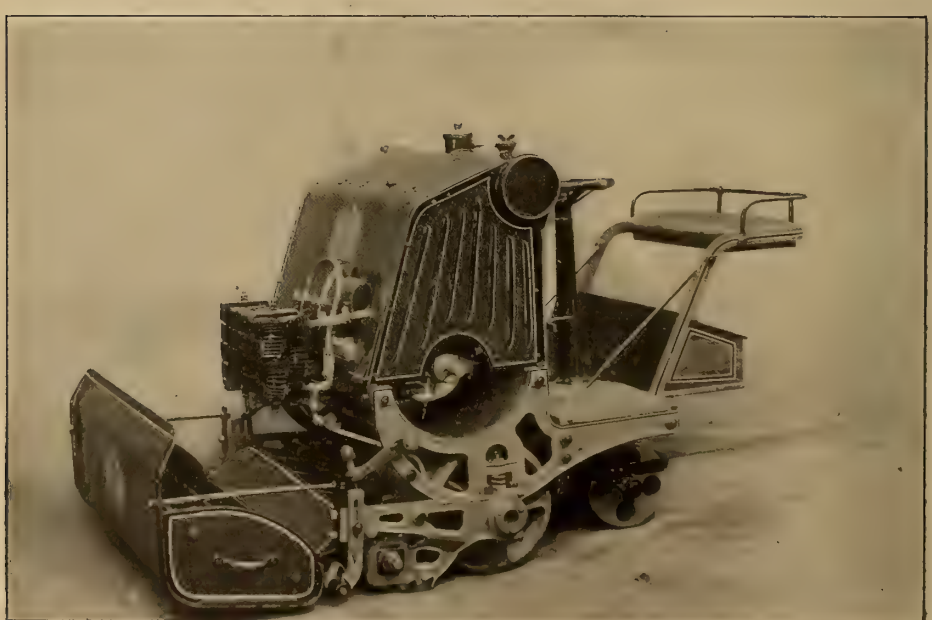


FIG. 9.—MOTOR LAWN MOWER. A. SHANKS & SON, LTD., ARBROATH, SCOTLAND

unfettered. This feature gives to this motor the greatest hauling power it is possible to obtain from any motor of a given weight, as the entire weight rests on the three travelling wheels, and no one wheel can slip by itself, the fundamental point of agricultural traction being grip of the ground, beyond which no amount of power will avail, and great weight is not permissible. Another feature is the carburetor, which burns either common petroleum oil or petrol. The engine is started on petrol and run for a minute or so, and then the driver may turn on oil or continue running on petrol. The cost of running on oil is less than half the cost of running on petrol. A removable tipping lorry is neatly arranged to fit on the rear of the tractor itself, to carry one or two tons, and when thus loaded the tractor has ample power and grip of the ground to haul three or four tons in a trailer behind. The following information will show what these motors will approximately accomplish with 1½ gallons of fuel (either oil or petrol) in one hour:—

Driving threshing machine;

Mow two acres of grass;

Mow and tie nearly two acres of grain;

Plough nearly one acre;

Haul three tons six miles.

In many cases the motor is employed with two wheels only, the frame being connected with carrying wheels, which carry agricultural appliances or otherwise enable the motor to be operated as a part of a combination vehicle. These two wheels, although motor propelled, are steered in the usual way. Three speeds (2½, 3½ and 7 miles an hour) are provided in both directions.

The fittings for connecting the tractor with various agricultural machinery are all designed so that the connection and disconnection can be quickly and easily effected, rarely occupying more than ten or fifteen minutes. The general usefulness of this type of tractor will, therefore, be apparent. It can also be employed as a portable engine for driving stationary machinery.

The Ivel agricultural motor is another machine of the same general type as the preceding, and is in fairly extensive use. It is designed specially for operating agricultural machinery. In Fig. 5 one of these machines is shown hauling a plough, and Fig. 6 shows its use for stationary purposes driving a Merryweather pump. It can be adapted for connection with almost any type of agricultural machine, and sometimes with two or three.

The motor is provided with two traction wheels and a front steering wheel, and is operated by a double-cylinder petrol engine, though it can also be adapted for the use of paraffine or alcohol.

These machines have been supplied in considerable numbers for use all over the world.

Fig. 7 illustrates a motor road roller built by Messrs. Barford & Perkins, of Peterborough. This firm have for some time constructed water ballast rollers, and the machine now under notice is of this type, adapted for propulsion by a petrol engine. The hind roller holds half a ton of water. Each roller is fitted with gearing giving two speeds, and when running on the slow speed the machine will climb a gradient of 1 in 7. The engine cylinder is water-cooled, a sufficient body of water being carried in the circulating tank to enable the cooling to be efficiently done without the aid of a fan or pump. The tank is placed over the hind roller, so that its weight is in a useful position, while at the same time its height renders a pump unnecessary, the circulation being automatic. A friction clutch on the motor spindle allows the engine to run free for starting, and, when running, can be instantly released at will. Two speeds, either forward or backward, are arranged for, viz., one mile and three miles an hour, the change being conveniently made from the driver's seat.

FIG 10—ATLAS TRUCK, HAULING PLOUGH FOR LAYING GAS MAINS. KNOX MOTOR TRUCK CO., SPRINGFIELD, MASS.

For several years petrol motive power has been employed in connection with lawn mowers and like machines, and in Figs. 8 and 9 two examples of this combination are illustrated.

The former of these is one built by Messrs. Ransomes, Sims & Jefferies, Ltd., of Ipswich, this firm being the pioneers of this class of machine and one of the largest constructors of them.

The machine illustrated is intended for use on large level surfaces, such as cricket grounds, etc. It has a 6 B. H. P. petrol motor, with magneto ignition, mounted on the main frame to which the driving rollers, seats, etc., are also attached. The power is conveyed by chain gearing to the driving rollers and the cutting cylinder through a reducing gear, which also acts as a clutch for starting and stopping the machine independently of the motor. There is a separate clutch for putting the cutting cylinder out of gear when it is required to roll the grass only. The cutting cylinder is fitted with patent divided knives, patent single-screw adjustment, and, with the bottom blade, front rollers and grass box, is carried on a separate frame, hinged to the main frame to allow it to follow the inequalities of the ground.

The mower illustrated in Fig. 9 is built by Messrs. Alexander Shanks & Son, Ltd., of Arbroath, Scotland. It is designed to cut 42 inches, and weighs 19½ cwt. The whole of the mechanism is protected by sheet-iron casing with hinged cover, admitting of easy access to any part. This mower is fitted with reversing gear, by means of which it can be stopped, backed when necessary, and restarted without stopping the engine. The front portion of the machine being hinged and free to move, the cutter is able to adapt itself to irregularities in the ground, and the driver can also throw the cutter out of gear and raise it from the ground, without leaving the seat, by means of hand levers. These facilities are most useful when backing the machine, and they safeguard the cutter, and, indeed, the whole machine, from shock when travelling from place to place, crossing carriage drives, etc. This machine makes a very efficient roller, as the weight is concentrated over the main drum, the cutter being lifted from the ground.

Current Topics

THE subject of the use of mechanical stokers on locomotives, dealt with in detail elsewhere in this issue, brings forcibly to notice the fact that whatever advances may be made in the mechanic arts, the physical limitations of the human element must be taken into consideration.

As Kipling has sung, in "McAndrew's Hymn":

> "What I ha'e seen since ocean steam began
> Leaves me no fear for the machine, but what
> about the man?"

Already the limitations of the man appear on the heavier locomotives on the American railways, and the expedient of having more than one fireman having failed of success, the present method has necessarily taken the shape of shorter turns, powerful men being able to serve for only about three hours at the task of handling continuously as much as five tons of coal per hour.

Mechanical stokers may be made successful for certain special service, but it seems as if the only permanent solution of the problem appears in the removal of the steam plant from the tracks, and its transfer to the stationary power house; in other words, in the general adoption of electric traction.

It has been doubted whether there would be any material gain in economy over the present steam locomotive system by the change to stationary power houses and electric locomotives, since the tests at St. Louis and elsewhere have confirmed the fact, often maintained before by railway engineers, that the locomotive is not a very wasteful machine. The question of economy, however, is not the only one, and indeed it appears to be a secondary one, since the hauling capacity of the machine demands first attention. Economy of fuel is doubtless an important feature in all steam generating plants, but the true measure of efficiency is the economy of money, and the system which will permit the greatest returns to be obtained from the investment of a given amount of capital, is the most economical, even though the distribution of expenditures be different from that formerly obtaining.

THIS matter of total efficiency of a plant, or as Professor Rateau has termed it, the "global efficiency," is well brought out in the first of Mr. Cooke's papers on "Steam Boiler Efficiency," commenced in this number.

The efficiency of a steam boiler is often taken to mean its thermal efficiency, the proportion of the heat energy in the coal burned to the heat energy delivered in the steam, and this is, doubtless, an important ratio. It is an interesting fact, however, that

a steam plant of the highest thermal efficiency is not always found in those establishments which are paying good dividends to the stockholders, and the installation of an elaborate central power station of the most modern type is by no means invariably followed by a large reduction in operative expense.

The definition of engineering as "common sense applied to the use of materials" applies here as elsewhere, and it is upon the judicious use of common sense, which has been termed the most uncommon thing in the world, that total monetary efficiency of a manufacturing establishment must depend in great measure.

Thus, it may cost more to buy a high-grade coal, and the advantages of a cheaper grade may be forcibly presented, but unless the questions of handling both coal and ashes, relative number of employees demanded, delays due to low steam in emergencies, etc., are fully considered, the cheaper fuel may prove the most expensive in the end. An elaborate system, including complete central power station and equipment, may make a most efficient showing as regards the pounds of coal per horse power, but when the interest on the first cost of the equipments is taken into account, as well as the proportion to be written off for depreciation, the old outfit may not prove so expensive after all.

This does not mean that the greatest care should not be taken to install the best possible plant for every purpose, but it does mean that the aim always to be kept in mind should be the final efficiency in money, rather than the special efficiency of some one element, which may really not be the controlling element at all.

THE recent meetings of the Institution of Naval Architects were replete with valuable papers relating to one of the most important departments of British industry, and space here is available only for mention of some of the leading subjects discussed.

Dr. Schlick's scheme for steadying vessels by utilizing the gyroscopic action of a heavy rotating fly-wheel, was presented in its latest developments by Sir William H. White, and both the paper and the discussion showed that the apparatus is to be taken seriously, so that practical installations may soon be made. This matter of the influence of rotating bodies on shipboard may prove of especial importance in connection with the use of steam turbines.

The question of the applicability of internal-combustion engines on shipboard assumed importance at the meeting, as did papers on floating docks, fire-prevention at sea, and problems in marine design and construction. Some of these subjects we shall take up later, possibly in connection with a broad discussion of modern marine developments.

WE have illustrated and described elsewhere the magnificent donation which has been made by Mr. Andrew Carnegie in the house for the several national engineering societies in America, together with some comparison of the American building with the houses of the Institution of Civil Engineers, the Institution of Mechanical Engineers, and the Société des Ingénieurs Civils de France. Of the utility of such centres for engineering activities there can be no doubt, and it is not yet impossible that there may be seen in London some such structure in which the many powerful and active professional and technical institutions may find a common home. In New York the practical problems in connection with the joint occupancy of a single building appear to have been successfully worked out, so that feature of the subject has had a satisfactory solution, and the real question of importance in such an undertaking is financial rather than administrative.

DAVID SCHENCK JACOBUS

A BIOGRAPHICAL SKETCH.

IN the course of the development of the Babcock & Wilcox boiler the ability of a number of eminent engineers has been enlisted, and the latest of these is Dr. D. S. Jacobus, well known to engineers all over the United States as "Professor" Jacobus, of Stevens. "Of Stevens" Dr. Jacobus still is, but only as a special lecturer on experimental engineering, since he now holds the important position of advisory engineer to the Babcock & Wilcox Company, giving them the benefit of his wide experience in steam engineering and experimental practice.

David Schenck Jacobus was born at Ridgefield, N. J., in 1862, and received his early education there in a private school conducted by the Rev. A. B. Taylor, from which he entered the Stevens High School at Hoboken, N. J., winning, by competitive examination, a scholarship in the Stevens Institute of Technology, from which he was graduated with the degree of Mechanical Engineer in 1884.

Upon his graduation he was appointed instructor in the department of experimental mechanics, being associated closely in this work with Professor J. E. Denton, and filled this position and that of assistant professor until 1897, when he was made professor of experimental mechanics and engineering physics.

In connection with his college duties he did a great amount of expert work, involving investigations and reports on mechanical devices and processes. In many cases these reports were rendered to parties who desired to know whether there was a good field for investment, so that the commercial as well as the engineering side had to be considered; in other cases the work was of a strictly engineering character.

As an example of the first class of work, there might be mentioned tests and reports on various schemes for the development of power and for the economical production of some manufactured article; and as an example of the second class of work, tests made on power plants with reports as to methods of improving the efficiency, and tests of many steam motors and of turbines.

A good example of the latter class of work, or that of a strictly engineering character, is the installation of what are probably the most powerful counterweights ever employed in steam engines. These were placed on the crank discs and fly-wheels of the engines at the Manchester street station of the Rhode Island Company, Providence, R. I., in order to eliminate the severe shaking which occurred with the engines in their normal condition. As the engines drove alternating-current generators which were to be run in parallel, it was necessary to study the electrical as well as the mechanical side of the problem.

He was early in the field of refrigeration, making tests of machines and writing papers on the subject.

He also made experiments on acetylene gas in the early days of the development of that industry, and for a number of years examined and reported on the different makes of acetylene generating machines which were submitted to the New York Board of Fire Underwriters for their approval. He also made a great

many tests and reports for this board on automatic fire sprinkler heads and on fire sprinkler systems.

In 1903 the Council of the American Society of Mechanical Engineers appointed him chairman of a committee to suggest a standard tonnage basis for refrigeration. This committee presented a report in 1904, and were reappointed to prepare a code of rules for conducting tests of refrigerating machines. The preliminary report on this code has just been issued in the Proceedings of the society.

In 1906 he became advisory engineer of the Babcock & Wilcox Company. This made it necessary for him to practically give up his work at Stevens Institute, although it was arranged that he should remain on the faculty and deliver lectures on the practical side of engineering under the title of special lecturer in experimental engineering. After it was learned that he was to sever his long connection as a regular professor of the Institute, the degree of Doctor of Engineering was conferred on him by the trustees as an evidence of esteem.

Dr. Jacobus is a member of the following associations: The American Society of Mechanical Engineers, of which he has been manager and vice-president; the Society of Naval Architects and Marine Engineers; the American Society of Refrigerating Engineers, of which he has been president since 1906; the American Mathematical Society; the Society for the Promotion of Engineering Education; the American Association for the Advancement of Science, of which he was vice-president and chairman of Section D, Mechanical Science and Engineering, for the year 1904; the Franklin Institute, and an associate member of the American Institute of Electrical Engineers.

The list of professional and scientific papers of Dr. Jacobus would fill several pages of this magazine; they include the transactions of the above learned societies, together with the leading technical journals, and form most valuable contributions to the applied science of engineering.

WILLIAM LAWRENCE SAUNDERS

PRESIDENT INGERSOLL-RAND COMPANY, NEW YORK

SEE PAGE 191

INDEXED

CASSIER'S MAGAZINE

VOL. XXXII JUNE, 1907 No. 2

UNIV. OF CALIFORNIA LIBRARY JUN 5 1907

IRON ORE RESERVES OF THE UNITED STATES

A COMPARISON OF AMERICAN SUPPLIES WITH EUROPEAN RESOURCES

By John Birkinbine

In the last issue of this magazine there was published a thoughtful discussion of the question of the possibility of such a diminution of the supply of iron ore as to produce a material influence upon the production of pig iron in Great Britain. The author, Mr. Good, showed that so far as British supplies were concerned, there was no immediate cause for anxiety, and that the home product, together with the foreign supply immediately available, was ample for many years to come. We now have, as a fitting complement to the article by Mr. Good, the following paper, discussing, not only the iron-ore resources of the United States, but the production of other countries as well, showing that the matter is really an international question, and not one which can be confined to the supply and consumption of a single nation. Mr. Birkinbine is so eminently qualified to treat this great question at first hand that we believe his data and conclusions will be most acceptable to engineers and metallurgists on both sides of the Atlantic.—The Editor.

THE article in the May issue of CASSIER'S MAGAZINE upon "The Iron Ore Supply of Great Britain," opens with the assertion that the question is "of National importance," and proves that it is really an international problem for the British Isles. In fact, the iron ore supply of the countries which are prominent in producing iron and steel is an international one, and will become more so in the future.

Transportation facilities by land and by water bring together points far removed, and commercial development encourages producers of raw material to seek markets for mineral mined, and consumers to supplement local supplies by ores brought from distant points.

Iron ore is now an important factor of the commerce of the world, some countries which manufacture iron drawing largely upon others which have iron ore in excess of their apparent requirements.

While the contribution of Mr. Good may be considered optimistic, he demonstrates that he has as much basis for his claims as those who have taken the pessimistic side, and have foreshadowed the exhaustion of the world's iron ore supply. As a loyal Briton, the future of his country is asserted as secure, first by reason of domestic ores, and, second, when these fail, by depending upon imported mineral. In the latter, other countries, accessible by vessels, may also claim practically equal advantage, and the arguments advanced in the contribution to CASSIER'S MAGAZINE, assuming the permanence of the iron ore supply of Great Britain, can be applied to the United States,

Copyright, 1907, by the Cassier Magazine Co.

to show that its domestic reserves, and the possibility, if necessary, of drawing on foreign supplies, promise long life for the iron and steel industry.

This review of the iron ore situation in the United States is not intended to flaunt in the face of any other nation claims of superior natural resources, or more intelligent utilization of them. The statements of British, German and Swedish writers may be accepted as correct, for such acceptance should entitle the employment of the same basis of reasoning to the iron ore reserves of the United States.

If the older settled countries are still discovering new iron ore supplies in districts which have long been exploited for this mineral is it unfair to anticipate similar results in a newer country, covering much greater territorial area, in which the entire range of geological formations are known to exist?

The facts are that new "finds" are continually being made in iron-ore fields where exploitation has been most active, or where mining operations have covered the greatest time interval. As this is written overtures are being considered which will transfer to a steel works the control of mining properties first wrought about 1740, but which have, by reason of complications (now removed) been dormant for years, a transaction which will require one million dollars for its consummation.

Another instance where the consideration paid approximates an equal amount, is the purchase of an ore body adjacent to a mine which was active for half a century, and was practically abandoned.

There are few sections of the United States where iron ores have been mined, which fail to indicate liberal reserves that have been unwrought or imperfectly exploited, and in portions of the country where ore has not been won, explatory work has demonstrated that deposits of importance may be expected.

In the eastern portion of the United States large bodies of magnetite offer excellent opportunities for beneficiating processes. In the West ore deposits are wrought which are remarkable for their extent, and also for the character of the mineral.

In discussing the problems of iron-ore supply and drawing comparisons, it will be interesting to note the status of various countries which are important producers of iron ore, or which use iron ore liberally, and to note the dependence of each of the latter class upon domestic and foreign sources.

This may be best shown graphically by two plates upon which contemporaneous data of iron ore and pig iron production are illustrated. The tardiness which characterizes the publication of some records, however, prevents the completion of the data. In Fig. 1 is shown the annual production of iron ore by the United States, Great Britain, Germany (including Luxemburg), Spain, France, Sweden and Russia, from 1889 to 1905. This interval of seventeen years is selected because during that period the writer collated for the United States Geological Survey the production of iron ores in the United States, and published in connection with this data the records of other countries. Production for a single decade would fail to indicate some comparisons of interest, and while some of the records obtainable cover more than seventeen years, the hiatuses would vititate the value of other continuous data.

As the Lake Superior region at present furnishes 80 per cent. of the iron ore mined in the United States, its marvelous development and relative output are also indicated, while the difference between the total for the country and that of the Lake Superior region demonstrates how imperfectly the ore reserves of other portions of the United States are at present utilized. The iron and steel industry, like other manufactures, follows lines of least resistance, and

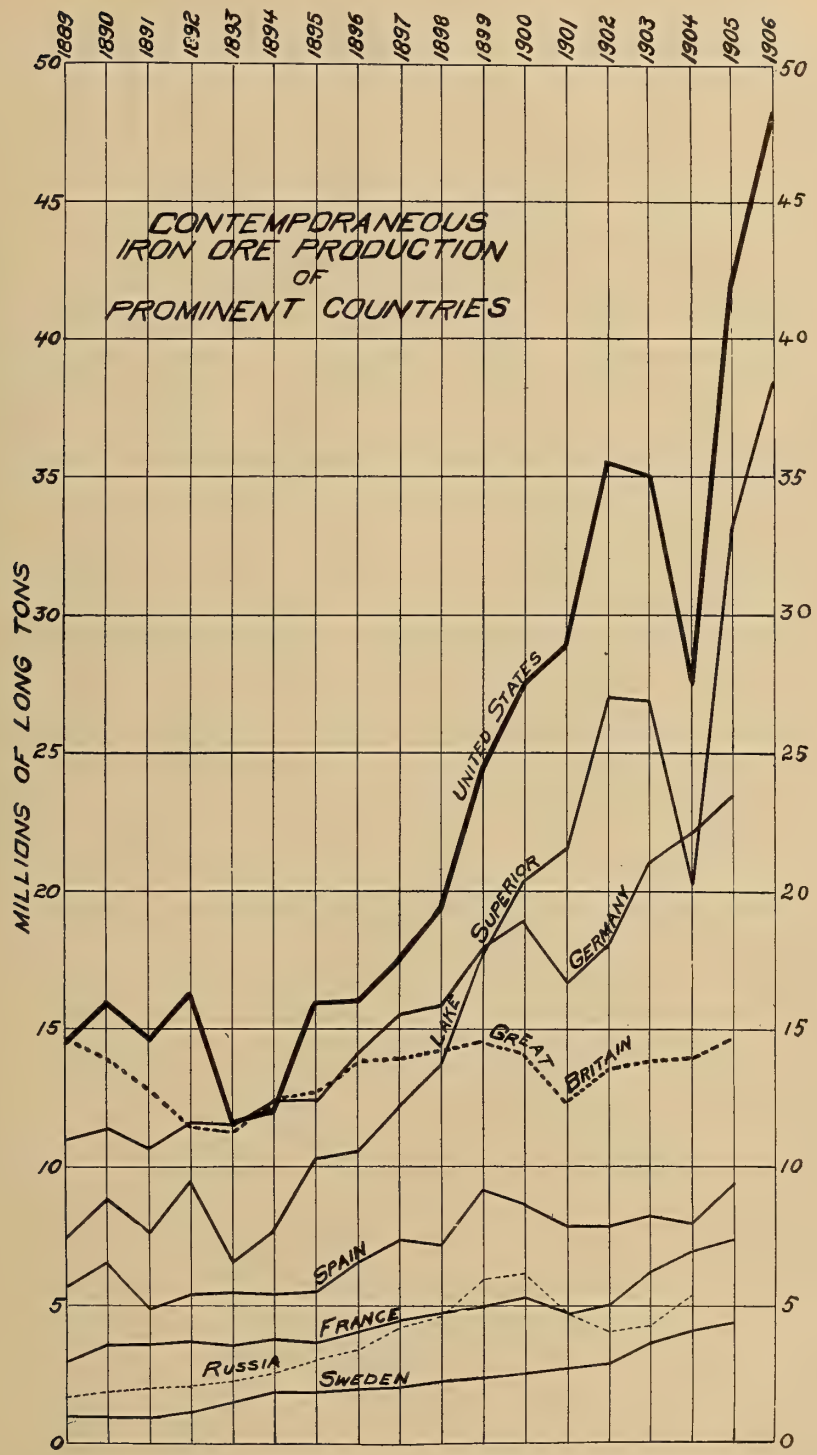


FIG. 1.—IRON ORE PRODUCTION

these lines have led to a liberal use of the ores obtained from the Lake Superior region, not merely because of their abundance and their high percentages of iron, and in many cases low perecntages of phosphorus and sulphur, but also because the iron producer is relieved of the risk and annoyance of mining. He cannot be blamed for neglecting ores which are close by when he can enter a competitive market, and select ores of desired composition, mined for and shipped to him. But the larger enterprises have corraled many of the lake ore deposits, and now most of them are owned or controlled by iron and steel producing companies.

The fact is not generally appreciated that one-third of the output of the Lake Superior region in 1906 came from ten mines, each of which furnished from one to two and a half million tons of iron ore, and that with the exception of Great Britain and the German Empire, no country has supplied in any year as much iron ore as came from these ten mines in 1906.

The Lake Superior region, in the year 1906, supplied over thirty-eight million tons of iron ore, and the total for the United States is estimated at about forty-eight million long tons. The figures for the year 1906 for other countries are not available, but it is probable that the Lake Superior region contributed as much iron ore in 1906 as the two greatest European pig-iron producing countries, viz., Germany and Luxemburg, and the British Empire. If the whole of the United States is considered, the 1906 total will exceed the combined totals of Germany and England, and the next most important iron ore producing country, Spain.

In the above statements only the gross tonnage, not the percentage of iron in the ores, is considered. If the latter was taken into account the difference would be still greater. The bulk of the augmented output of iron ore in the United States in the period under discussion came from the Lake Superior region, and much of this development can be localized, as in the above group of mines, or, as in the case of the State of Minnesota, which, prior to the year 1884, produced no iron ore, but in 1906 contributed twenty-five and a half million long tons.

In defending his claim that the domestic iron ore reserves are ample, Mr. Good shows that "the consumption of British iron ores has been steadily decreasing for more than twenty years," and in support of the sufficiency of American ore reserves, the limited increase in the quantity of domestic iron ores, outside of those coming from the Lake Superior region may be mentioned with equal propriety.

A glance at the diagram presented suggests how limited has been the exploitation of the iron ore mines of the United States outside of the Lake Superior region, and a knowledge of the location and productive history of the iron ore deposits of the country emphasizes the fact that many sources of local supply have been abandoned, or allowed to lie unutilized, while the Lake Superior ores have covered long distances to take the place of local mineral.

Iron ores near to points of consumption which have not been exploited compare favorably in metallic yield with ores utilized in other countries, and are richer than some of the material to which Mr. Good looks forward as the basis upon which he rests his prediction for the future of the iron industry of Great Britain. Liberal allowance may be made for difference in wage rate, favoring Great Britain, without materially diminishing the apparent available ore reserves of the United States.

While Fig. 1 illustrates the past and present position of the important iron ore producing countries, it should be considered in connection with Fig. 2, which presents for a similar interval the pig iron output of various countries. While full contemporaneous data are not obtainable, the diagrams,

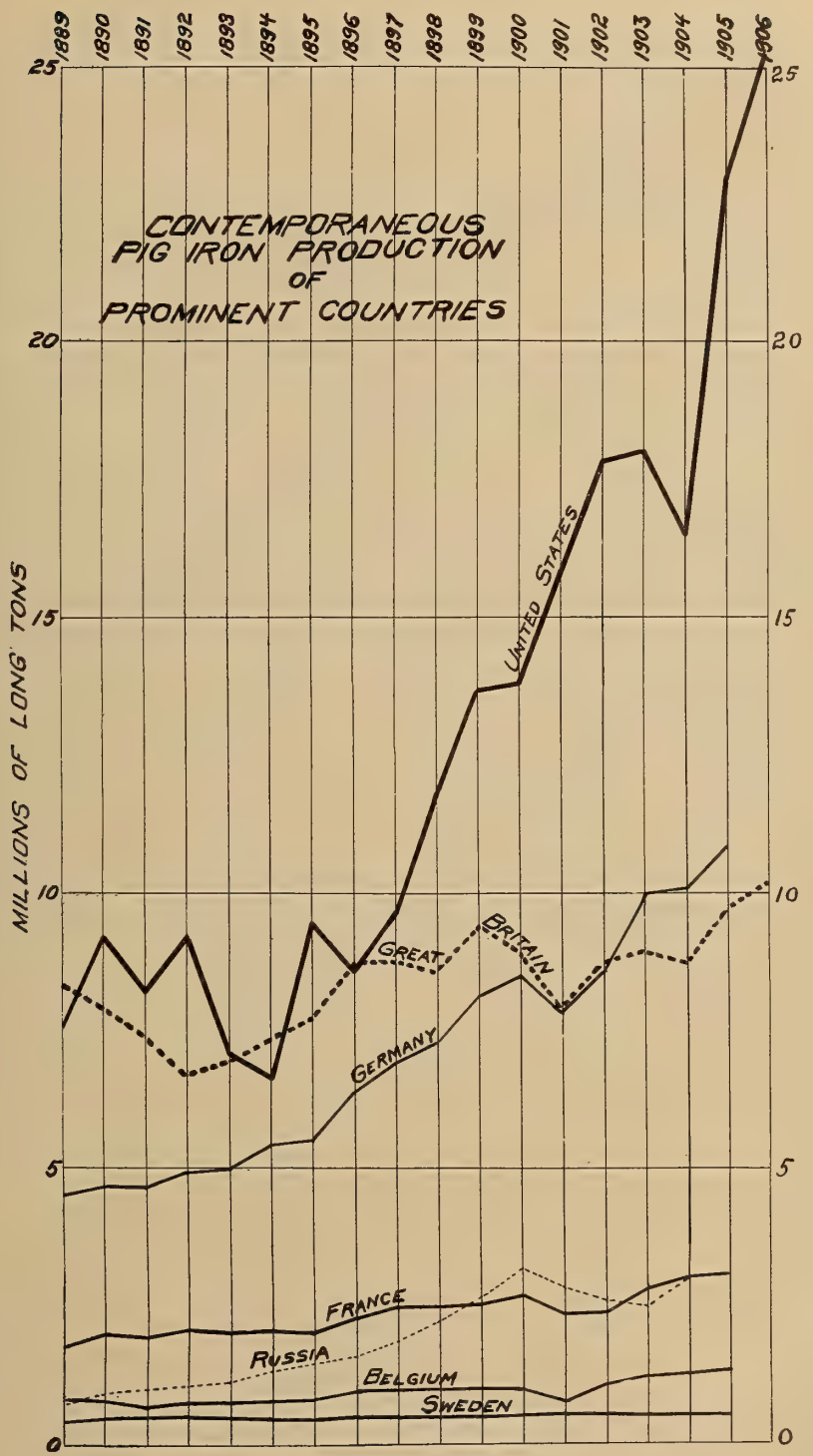


FIG. 2.—PIG IRON PRODUCTION

taken together, demonstrate the relative importance of the countries in Western Europe and the United States, as producers and users of iron ore as far as quantity is concerned, but to make complete comparison the relative contents of the ores mined and used cannot be overlooked, a feature to which Mr. Good gave no attention in his statement of Great Britain's position.

At the risk of burdening the reader with an array of figures, statements of the quantities of iron ore won from and pig iron produced in various countries are presented, the purposes of these being to supplement the graphic representations and illustrate the status of each country which has been discussed.

The iron ore output in the United States in 1905 was 42,526,133 long tons, and in the same year the pig iron output was 22,992,380 long tons. The quantities for the year 1906 are: Iron ore, 48,000,000 long tons (estimated); pig iron, 25,307,191 long tons.

The imports of iron ore into the United States now approximate one million tons annually, or about two per cent. of its consumption. The duty of forty cents per ton undoubtedly influences the amounts drawn from foreign countries, but this duty, on the other hand, has the effect of encouraging the importation of ores of superior character. If the domestic supply is at any time in question, a removal of the duty would make the United States a competitor with Europe for some of the ore upon which the blast furnaces of Western Europe rely.

Great Britain in 1905 produced 14,590,703 long tons of iron ore and 7,344,786 tons of iron ore were imported, about six million tons of which came from Spain, but little ore being exported. The maximum production of pig iron was reached in 1905, viz., 9,608,086 long tons, from 345 active furnaces. According to the British Blue Book, there was consumed in the manufacture of this pig iron 23,050,782 long tons of iron ore, scrap, roasted pyrites, etc., or an average of 2.4 tons per ton of pig iron. The same authority states that in 1905 the 14,590,703 tons of native iron ores mined was equivalent to 4,760,187 tons of pig iron made, while the 13,774,282 tons produced in 1904 yielded 4,524,412 tons of pig metal, indicating that approximately three tons of native ore are required to make a ton of pig iron.

Germany and Luxemburg, in the year 1905, mined 23,444,073 metric tons of iron ore, its greatest output; the imports of iron ore, chiefly from Spain and Sweden, were 6,085,196 metric tons, and the exports 3,698,563 tons, principally Minette ore to France. This would show a total of 25,830,706 metric tons of iron ore used. Omitting from consideration unknown amounts of scrap, mill cinder, etc., an average of 2.38 tons of iron ore were required per ton of pig iron produced in 1905 (viz: 10,875,061 metric tons, the maximum for the country). If the imports of Spanish and Swedish ores, which, according to Mr. Schrödter, yielded from 49 to 65 per cent. of iron, were credited with the metal they produced, the average requirement of local ore per ton of pig iron would be considerably augmented.

In 1905 France mined 7,359,000 metric tons of iron ore, the maximum, importing in that year 2,151,633 metric tons, principally from Germany, Spain and Algeria, the exports being 1,355,591 metric tons, the greater portion going to Belgium. Its pig iron production of 3,076,550 metric tons required the smelting of about two and two-third tons of ore per ton of metal, and if the rich foreign imports were credited with the metal they produced the proportion of domestic ores required would be still greater.

Spain reached its maximum iron ore production in 1905, viz., 9,395,314 metric tons, of which amount 8,590,483 tons were exported, principally to Great Britain and Germany. The

pig iron production in 1905 was 383,100 metric tons. It is estimated that over two tons of iron ore were required per ton of pig metal.

Belgium produces considerable pig iron, the maximum being 1,350,450 metric tons in 1905, but the blast furnaces depend almost entirely on imported ores, local mines supplying but about 200,000 metric tons annually. Nearly two and three-quarter tons of foreign and domestic ore, cinder, roasted pyrites, etc., are consumed per ton of pig metal produced.

Sweden is well supplied with iron ore deposits, and since the exploitation of the mines in Swedish Lapland the production has shown an almost uninterrupted increase, the maximum of 4,365,967 metric tons being mined in 1905. The bulk of this ore is exported, chiefly to Germany and England. Sweden reached its maximum production of pig iron in 1905, viz., 539,437 metric tons, consuming about two tons of iron ore per ton of pig metal.

The pig iron production of Great Britain, Germany, France, Spain, Belgium and Sweden combined in 1905 practically equaled that of the United States in 1906, while the aggregate of the iron ore mined in these six countries in 1905 was 23 per cent. greater than in America in 1906.

The United States is now consuming, including the iron ore imported, about 1.9 tons of material per ton of pig metal. Therefore, as to quantity, Europe is drawing upon its iron ore resources more rapidly than the United States, and if the leaner ores, not now utilized, offer encouragement for future supplies in Western Europe, there is a proportionally greater margin of expectation for the United States.

Owing to the tardiness with which statistics are published, contemporaneous data concerning Russia and Austria-Hungary, the other two important pig iron producing countries, are not at hand, but Russia in late years mined four to six million tons of iron ore annually, producing from two and a half to three million tons of pig iron, and it is practically dependent on local ores, using about two tons of these per ton of pig metal.

Austria-Hungary is now mining about three and a third million tons of iron ore per annum, and producing one and a half million tons of pig iron.

Of the remaining countries Italy is now mining about 400,000 tons of iron ore, the major portion of which is exported. Norway about 50,000 tons, Portugal 15,000 tons, Greece 350,000 to 400,000 tons, and Algeria 600,000 tons, practically all of which are exported.

The United States is using iron ore more rapidly than any other country, but is producing as great a quantity of pig iron from a given amount of ore as any other nation, and its blast furnaces smelt a richer mixture than the average ore fed to the plants of Western Europe.

The problem is to be studied from the standpoints of deposits now exploited, of those unwrought, but concerning which ideas of their extent and character have been formulated by exploratory work, and of those whose locations are made known by prospecting, with allowances for probable iron ore supplies suggested by geological conditions.

The United States, by its phenomenal production of iron and steel and incident liberal use of iron ores, has invited attention to the depletion of a mineral found in every State of the Union, and present in neighboring countries in volume such as to encourage faith in the future of iron manufacture on this continent. If the study of the iron ore reserves is undertaken in connection with present or possible fuel supplies, with consideration of prospective producing and consuming centers, the time when iron may be a "precious metal" or the available supply of iron ore become exhausted may be found so far in the future as to allay any anxiety. for a long time to come.

EFFICIENCY IN STEAM BOILER PRACTICE—II

PRACTICAL EFFICIENCY AND EXAMPLES OF EFFICIENT MODERN STEAM BOILERS

By Percival Cooke

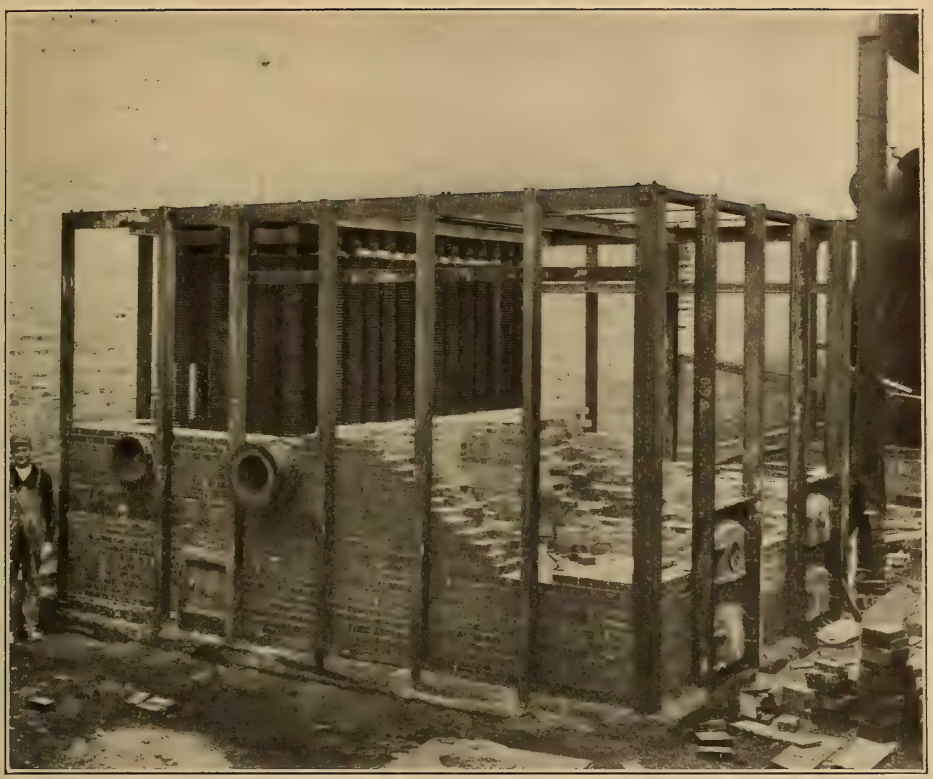
In the first of these papers the author discussed the principles of efficiency from the viewpoint of the manufacturer, showing the essential details upon which efficient operation depends. The present paper describes some types of modern efficient steam boilers, both for land and marine service, showing the extent to which the theoretical demands for efficiency have been met by builders of steam generators.—The Editor.

IN practical steam boiler working efficiency is not to be attained merely by the application of theoretical principles, however correct and well-founded such principles may be. The object to be aimed at, from the commercial point of view, is the production of dry steam at the lowest possible cost, and if this is to be successfully accomplished the practical side of the question must be given thorough consideration. The attainment of a high theoretical standard of efficiency involves costly installation and expensive organization quite beyond the requirements of manufacturing industry; hence the degree of efficiency to be attained, and the methods to be adopted in its attainment must, from the commercial point of view, be governed by practical considerations of initial capital outlay and progressive working costs.

The annual coal bill is the standard by which the operative efficiency of commercial steam-raising plant is measured by the manufacturer. Every ton of coal consumed by a boiler, whether economically utilized or wasted, will be included in the coal bill, and must consequently be paid for. It follows, therefore, that if the coal bill is unduly high in proportion to the power generated, the manufacturer is not obtaining the full value of his fuel expenditure; in other words, the economical steam-raising efficiency of his generating plant is not as high as it should be.

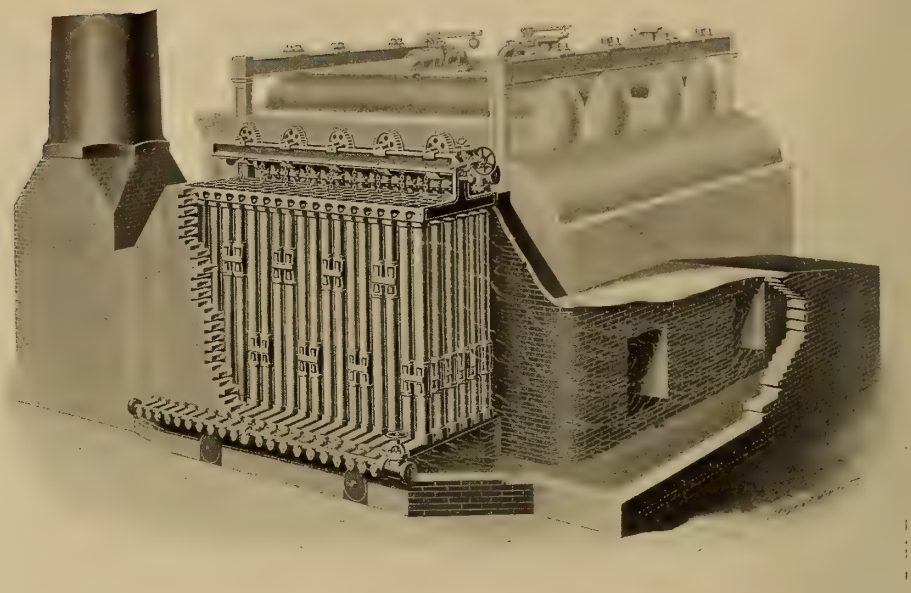
This state of affairs is not to be effectively remedied simply by having recourse to any particular efficiency-increasing device or appliance, such as feed-water heaters and purifiers, mechanical stokers, superheaters, or thermal storage vessels. Individually, these accessories are of great value when applied to boilers in a fit condition to receive them; but the mere application of any one appliance, whilst to a certain extent productive of good results, is in no way conducive to really successful and economical steam raising without the fulfillment of the ordinary requirements of efficiency of the boiler. Collectively, the installation of the appliances enumerated above would, in the case of almost any boiler, naturally result in a very considerable increase of efficiency and economy of fuel; but, on the other hand, the cost of installation would be so excessive as to be quite beyond the limit that a competitive business organization would care to afford.

Before resorting to special and expensive appliances with a view to increased efficiency, the existing state of the boiler plant should be thoroughly investigated, and all causes productive of waste of fuel or other inefficiency should be obviated to the fullest possible extent. The conditions under which combustion takes place in the furnaces should be cor-



FOSTER INDEPENDENTLY FIRED SUPERHEATER. POWER SPECIALTY COMPANY, NEW YORK

rected, particular attention being given to the regulation and admission of the air supply; perhaps the draught may be too powerful, resulting in the too rapid volatilization of the cone, and the consequent production of unconsumed smoke, and soot-covered and ineffective heating surfaces. A too powerful or too concentrated air supply is a frequent cause of uneconomical and inefficient fuel consumption. Air should be admitted above the level of the fire, as well as below the grate bars; this was fully explained in Part I. of this article. Attention should be given to brickwork settings and baffles; it pays well to keep them in good condition; otherwise the infiltration of air through niches and crevices potentially reduces the temperature of the gases of combustion. For this reason low temperature in flues and economizers are not necessarily indicative of efficient heat absorption; they may be due to air infiltration through faulty brickwork, and on this account pyrometer measurements of flue temperatures should not be too implicitly trusted as an indication of the efficiency of heat absorption. Cold feed-water and irregular feeding may also be opposing economical steam raising. Apart from the drawbacks of impaired durability and retarded circulation consequent upon the use of coal feed-water, the waste of fuel is considerable. The teratment of feed-water and the value of high temperature feed have already been discussed at length (see Part I.). As far as practicable the whole of the heating surfaces should be utilized in imparting latent heat to the water. Cold feeding should be obviated to the fullest possible ex-

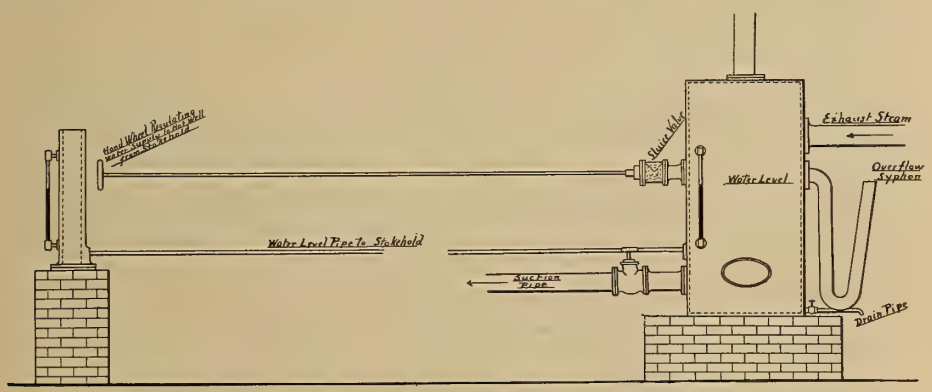


GREEN ECONOMIZER IN CHIMNEY FLUE. E. GREEN & SONS, LTD., WAKEFIELD. GREEN FUEL ECONOMIZER COMPANY, MATTEAWAN, NEW YORK

tent. If the plant is without feed-heating arrangements, a hot-well should be constructed and exhaust steam utilized for heating the feed-water. The installation of a hot-well is by no means expensive, and wherever there is exhaust steam at hand one should be constructed. A complicated series of coiled pipes is unnecessary; a hot-well of simple construction should give very satisfactory results. The steam should be passed into the hot-well near the top, above the level of the water, which acts as a surface condenser, any uncondensed steam being exhausted into the atmosphere through a pipe fixed to the top of the hot-well. An overflow syphon pipe should be fitted so as to prevent the water rising to the level of the steam supply pipe. If the hot-well is placed in a remote position with regard to the stokehold the water space should be connected by a small pipe to a gauge glass in the stokehold, so that the water level in the hot-well can be easily seen by the fireman. The sluice valve for regulating the water supply to the hot-well should be operated from the stokehold. If the plant is of large dimensions an economizer should be fitted, especially if the boilers are of cylindrical type. In fact, Lancashire and similar boilers are not generally to be recommended without economizers if high evaporative capacity is required. Although the cost of installation of an economizer is somewhat high, considerable saving is effected in the long run if the plant is well looked after. The efficiency of an economizer, when working under forced draught, may be appreciably increased by maintaining a slight flue-gas pressure round the tubes, which may be effected by lowering the chimney damper a few inches. A further step towards increased efficiency may be effected by arranging for continuous feeding. A continuous feed is much superior to an intermittent feed, and is more conducive to free circulation. Long-stroke, variable-speed, compound duplex pumps are to be preferred to the ordinary vertical donkey pump for boiler feeding. These, however, are not an absolute necessity unless existing pumps are unequal to re-

quirements. Plant of large dimensions should be equipped with auxiliary pumps in order to avoid danger or inconvenience in the case of breakdown of the main pumps. The same applies to boilers fed by injectors; a spare injector should always be at hand, ready for use in case of emergency. Injectors are at times apt to be somewhat inconsistent and unreliable, especially if of inferior quality; none but the best makes should be used for boiler feeding. A constant water level should be maintained; the best working level for

Marine practice essentially differs from land practice, chiefly with regard to feed-water, the quality of the coal used, and the methods of promoting draught. A sufficient supply of clean water is taken on board whilst in port, and, the engines being condensing, this water is evaporated and condensed in cycle, the only additional supply required being that to replace water lost by blowing down, should this be necessary, leakages, or the loss due to small auxiliary engines which exhaust into the atmosphere. Unless prevented



EXHAUST STEAM HOT WELL FOR HEATING FEED WATER

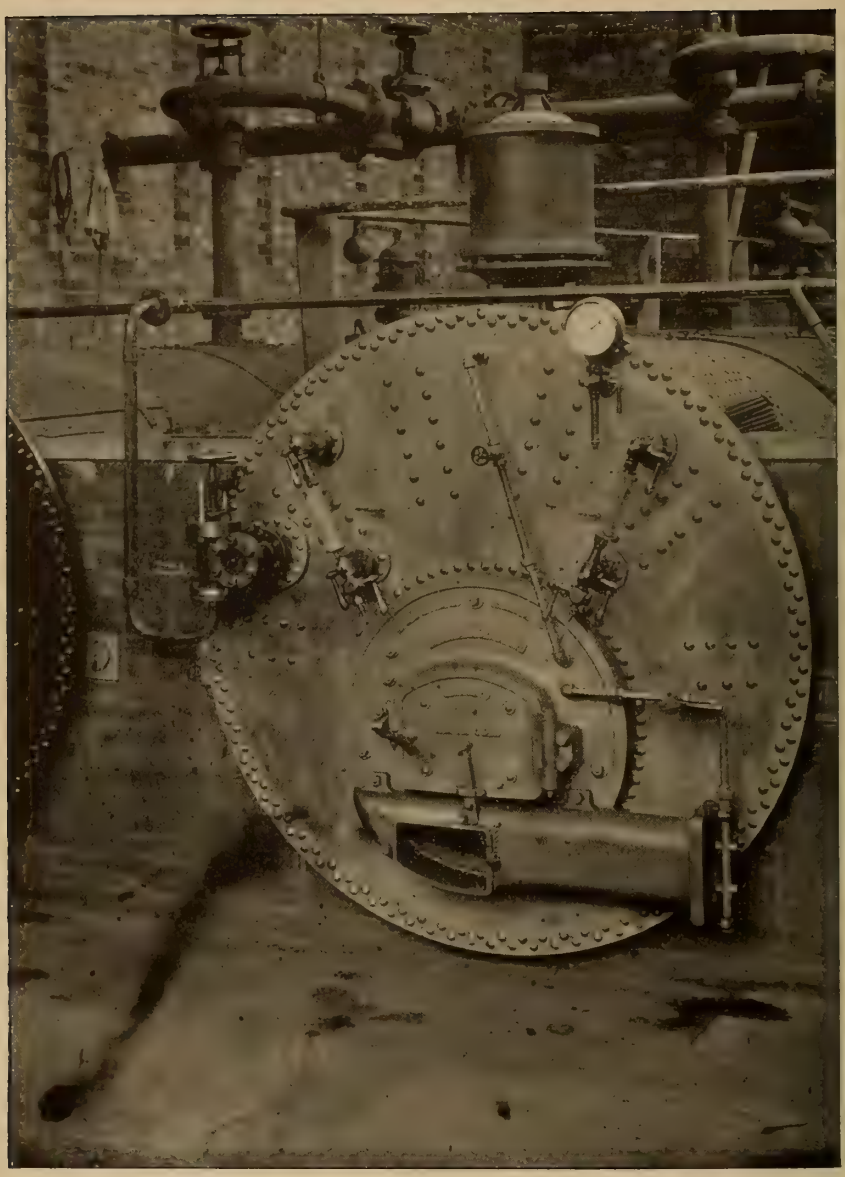
Lancashire and similar boilers is generally 9 or 10 inches above the furnace crowns, and for water-tube boilers about an inch below the centre of the steam drum. A constant water level cannot be maintained unless the feeding is continuous.

Careful attention to the foregoing details should considerably augment the efficiency of the plant, and after this stage the installation, where necessary, of mechanical stokers, superheaters, storage tanks, and similar accessories should be highly beneficial. At the same time, it should be remembered that however much the mechanical equipment of the plant may be improved, an intelligent and thoroughly trustworthy fireman is one of the most important essentials to efficient and successful working.

by restricted weight and space, an additional supply should be carried, or sea-water evaporators as an alternative. The water from jet condensers is almost as salt as brine, and necessitates frequent blowing down of the boilers. If efficiency is to be maintained at the boilers surface condensers should be employed. The water then remains pure and blowing down is unnecessary.

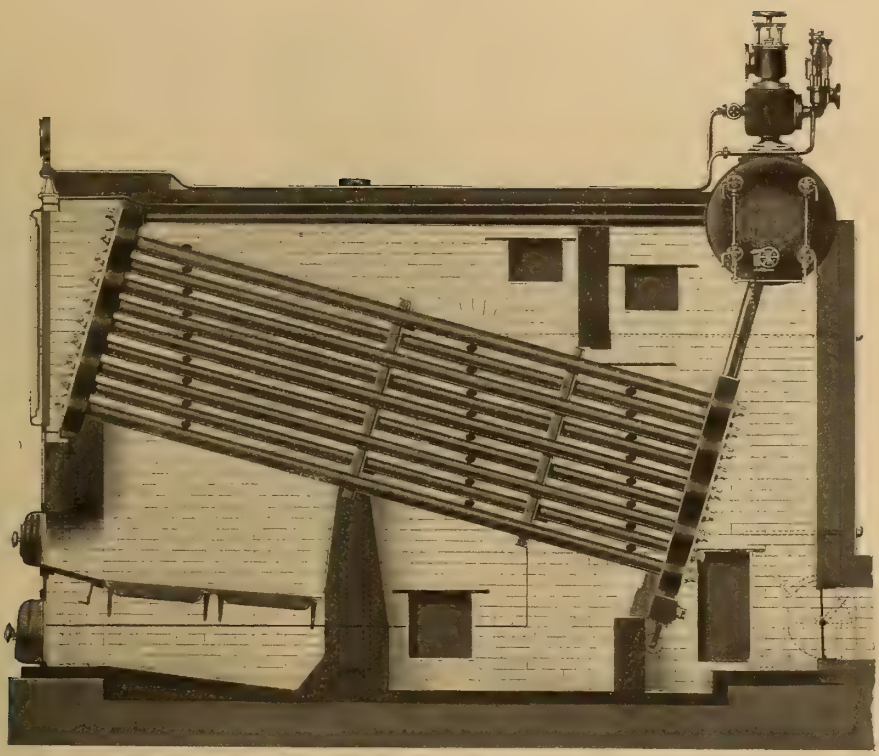
The coals used in marine practice are anthracite, which requires great skill in stoking, and dry bituminous coal, which, on the whole, is the most satisfactory, and is more generally used. Furnaces for burning anthracite should be high in the crowns, and the fires should be lightly worked.

Draught is obtained either by exhaust steam blast in the funnel, by



CORNISH BOILER WITH LOW GRATE FURNACE. MELDRUM BROS., MANCHESTER

air blast under the grate bars with closed ashpit, by induced fan draught in the funnel, or by fan draught into an airtight stokehold, the air being forced in until the pressure exceeds that of the atmosphere, the only outlet being through the furnaces. The exhaust steam blast is inefficient, and rapidly disintegrates the brickwork lining of the funnels. The closed stokehold, although costly, is the most efficient, and is generally adopted in naval practice. Its principal drawback is the danger which might accrue in the case of serious steam leakage or a broken gauge glass, as the stokehold is necessarily isolated, access to and egress from it being



BABCOCK & WILCOX BOILER. CROSS-DRUM TYPE

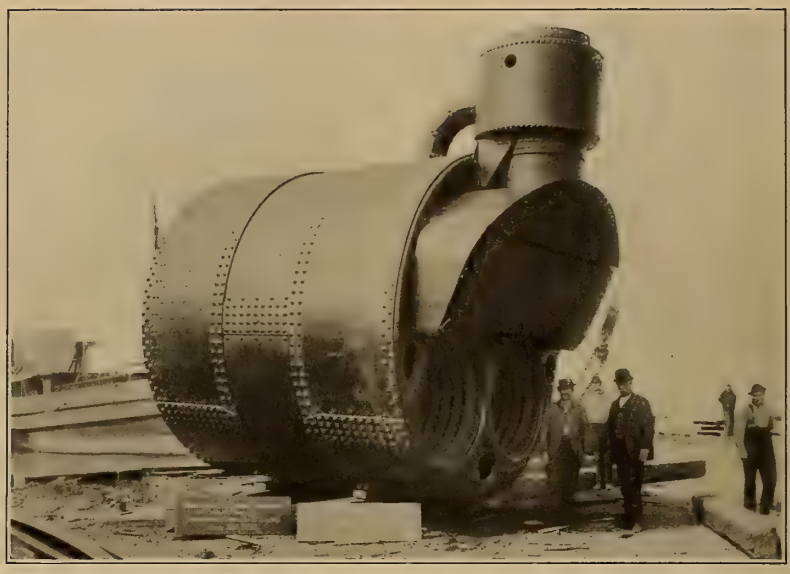
through airtight doors. This danger has, however, been almost entirely obviated by the use of safety screens fitted to the boiler fronts.

CORNISH, LANCASHIRE AND GALLOWAY BOILERS

The principal representatives of the cylindrical type are the Cornish, Lancashire and Galloway boilers, and these are so well known that a description of them is unnecessary.

The Cornish boiler, which was first adopted by Trevethick at the time of the introduction of the early Cornish engine, is a useful and serviceable steam generator for small mills, being of simple construction, inexpensive, and comparatively easy of manipulation. Under ordinary conditions it should easily evaporate seven or more pounds of water per pound of coal. The steam raising power of the Cornish boiler may be considerably increased by the adoption of the low-grate type of furnace, in which the grate is set deeper in the flue than usual, as will be seen from the illustration of a Cornish boiler fitted with a low-grate furnace constructed by Messrs. Meldrum Bros., of Manchester. The steam jet blowers presented the chief difficulty in the way of a low grate; this was surmounted by the use of special horizontal blowers fixed externally to the flue.

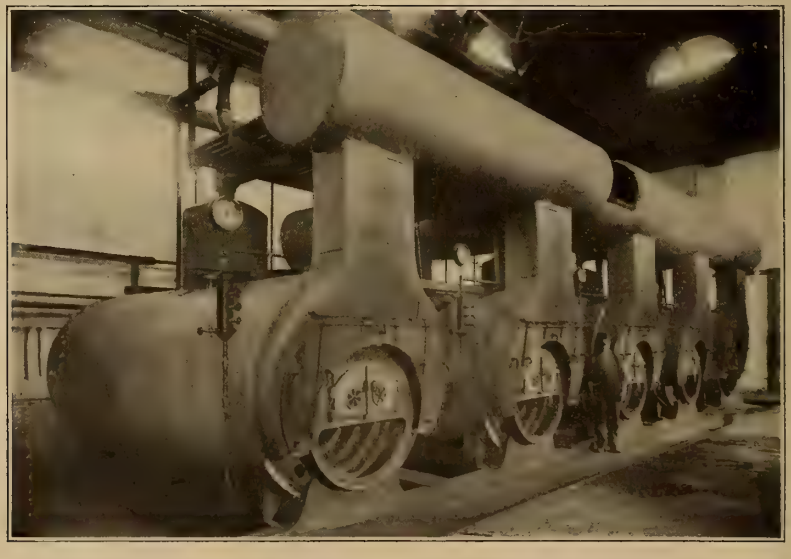
The Cornish boiler is occasionally constructed with the flue eccentric to the shell, with the object of facilitating cleaning; no advantage, however, results from this practice. The Lancashire boiler, which possesses a time-honoured record of reliability and good behaviour, is, generally speaking, the standard by which all other types of boilers are compared. Although certainly an efficient steam



CYLINDRICAL BOILER WITH CORRUGATED FURNACES FOR U. S. DREDGE CHARLESTON.
CONTINENTAL IRON WORKS, BROOKLYN

generator, it is by no means faultless, as its extreme rigidity of construction renders it particularly liable to strain and distortion of a severe character, and although this has been, to a certain extent, counteracted by the introduction of such excellent devices as the Adamson flanged seam, the Bowling hoop, and various types of corrugated and suspension furnaces.

If properly and carefully worked, the Lancashire boiler should generate nine pounds of steam per pound of good ordinary coal. It requires but little attention, as far as

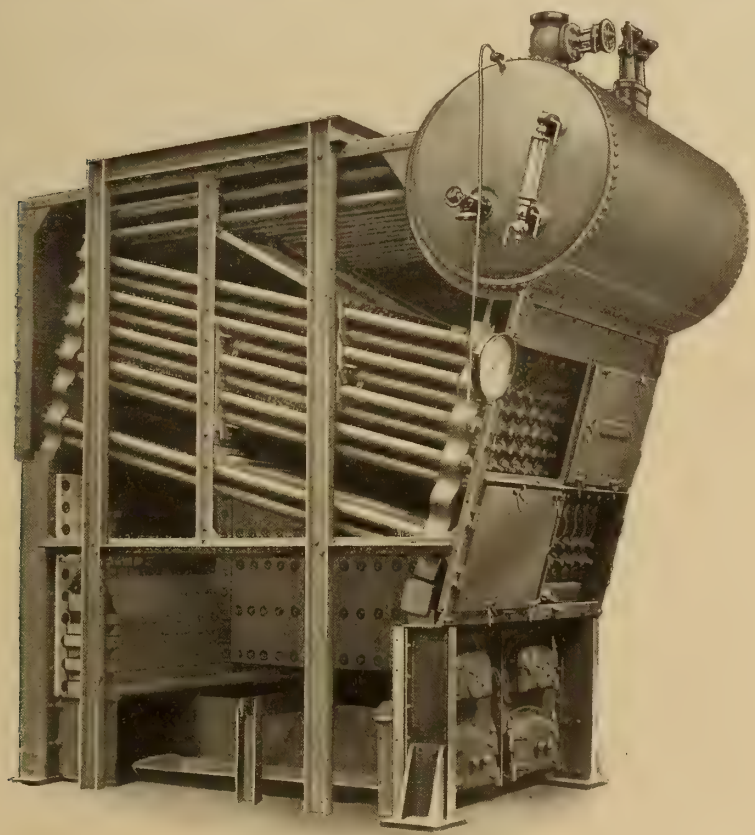


CYLINDRICAL BOILERS WITH CORRUGATED FURNACES AT THE MILBURNE PUMPING STATION
BROOKLYN WATER WORKS. CONTINENTAL IRON WORKS BROOKLYN

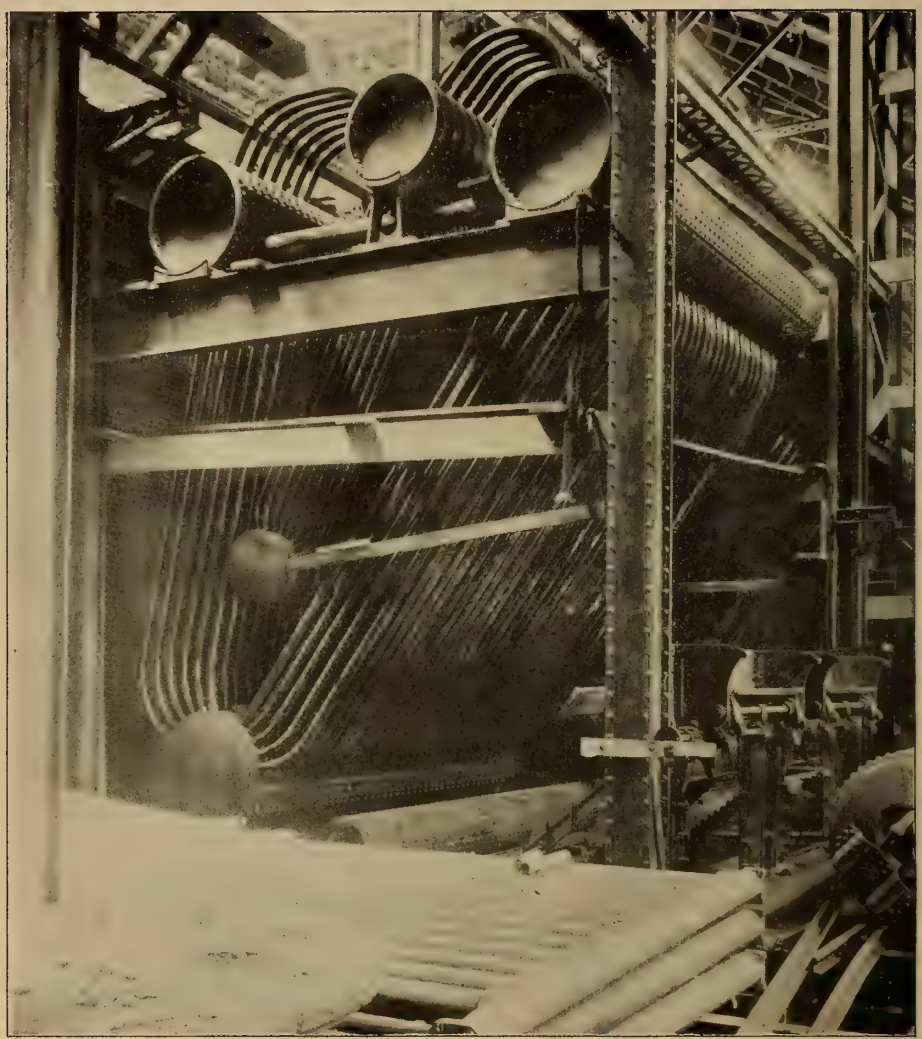
general repairs and brickwork renewals are concerned.

The Galloway boiler is one of the most efficient representations of the cylindrical type, its construction embodying a number of excellent features which render it at once a safe, powerful and highly capable steam generator. The cone circulation tubes characteristic of this boiler, which considerably augment its effective heating surface, are of great value in giving impetus to the circulation of the water, at the same time imparting great strength to the main oval flue, enabling it the more effectively to withstand the great pressure to which it is subjected. The Galloway boiler is not suitable for working with natural draught, owing to the retardation set up by the cross tubes; but when worked under forced draught it is capable of holding its own with almost any type of boiler, and is quite capable of evaporating ten pounds of water per pound of average coal. The cross tubes should be kept particularly clean, and should be scraped, if necessary, and well swilled out, at intervals of three or four weeks.

The external flues of Cornish, Lancashire, and Galloway boilers are frequently cramped, with the object of bringing the gases of combustion into closer contact with the plates. No advantage, however, is gained by so doing, as experience shows that the best results are to be obtained with moderately wide flues. Flues should in all cases be large enough for a man to pass through.



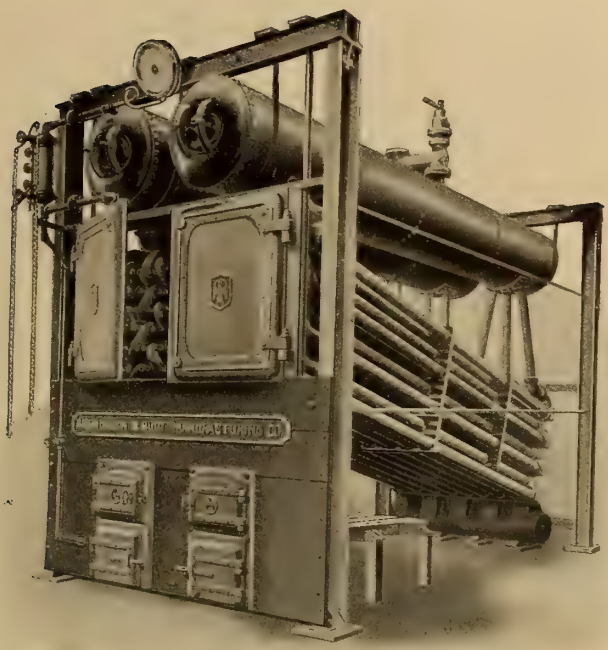
BABCOCK & WILCOX MARINE TYPE BOILER FOR LAND INSTALLATION



STIRLING BOILER AND SUPERHEATER

The gases of combustion should first pass through the bottom flue, and then through the lateral flues. This arrangement is most conducive to both economy and durability, provided that the boiler is properly blown down. In the case of small boilers under 18 feet in length, however, it is advisable to pass the flue gases through the lateral flues first.

Although most of the principal forms of water-tube boiler have had some early prototype, it can truly be said of the Babcock & Wilcox boiler that it is the pioneer of modern water-tube boilers. During the last forty years this boiler has been again and again remodelled and reconstructed in the light of ever-increasing experience and scientific research, until it has at last developed into what is undoubtedly one of the finest steam generators of modern times, embodying so many excellent features of design and construction as to make its claim for inclusion in the foremost rank of modern steam boilers altogether indisputable. Under many and widely varied circumstances it has proved itself so highly



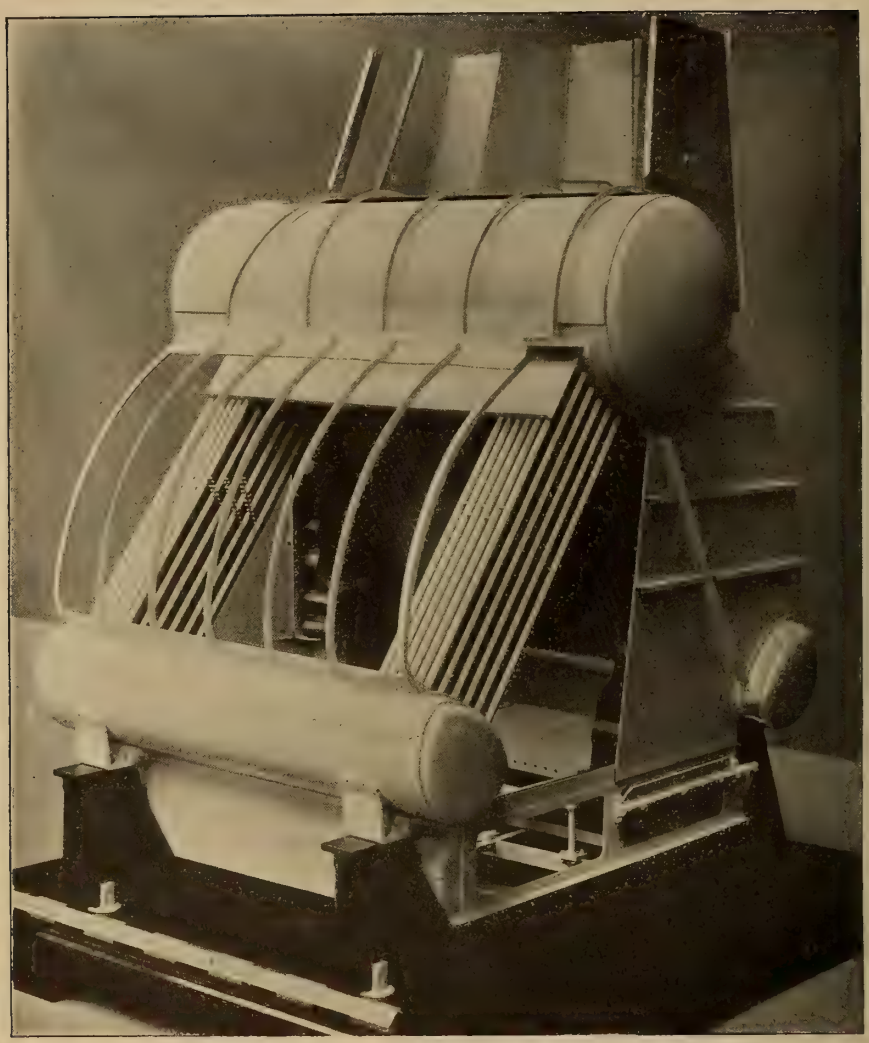
ROOT WATER-TUBE BOILER. ABENDROTH & ROOT MANUFACTURING COMPANY NEWBURGH, NEW YORK

efficient that it is considered by many engineers to be the first and best of all boilers. In view, however, of the general excellent types of water-tube boiler at present available, it is a somewhat conservative question as to the superiority of any one type over another type, for all boilers have their characteristic advantages, and also their disadvantages.

The distinguishing feature of the Babcock & Wilcox boiler is its sectional arrangements, by which each vertical row of circulation tubes communicates separately with the steam and water drum, the tubes, which are of the straight, semi-horizontal type, generally 4 inches in diameter, being expanded into staggered wrought-steel headers or manifolds, which are connected by short, expanded nipples to the cross boxes of the same material riveted to the under side of the drum. Access to the internal surfaces of the tubes is gained through openings in the headers, corresponding with the tube ends. These openings are closed and rendered water-tight by accurately fitted tube caps, held in position by wrought-steel clamps and bolts. The whole of the boiler is constructed of wrought steel, each part being self-sustaining, thus eliminating all tie-rods and stayed surfaces.

The cross-type of the Babcock & Wilcox boiler is so called because the steam and water drum lies transversely to the circulation tubes instead of directly over them. The drum is comparatively short, but is somewhat larger in diameter than in the ordinary type, and is connected to the front headers by long horizontal tubes. This type is very suitable for exportation, and for erection in situations to which access is difficult. It is frequently used for working in conjunction with reverberatory and similar furnaces.

The Babcock & Wilcox marine type boiler for land purposes em-

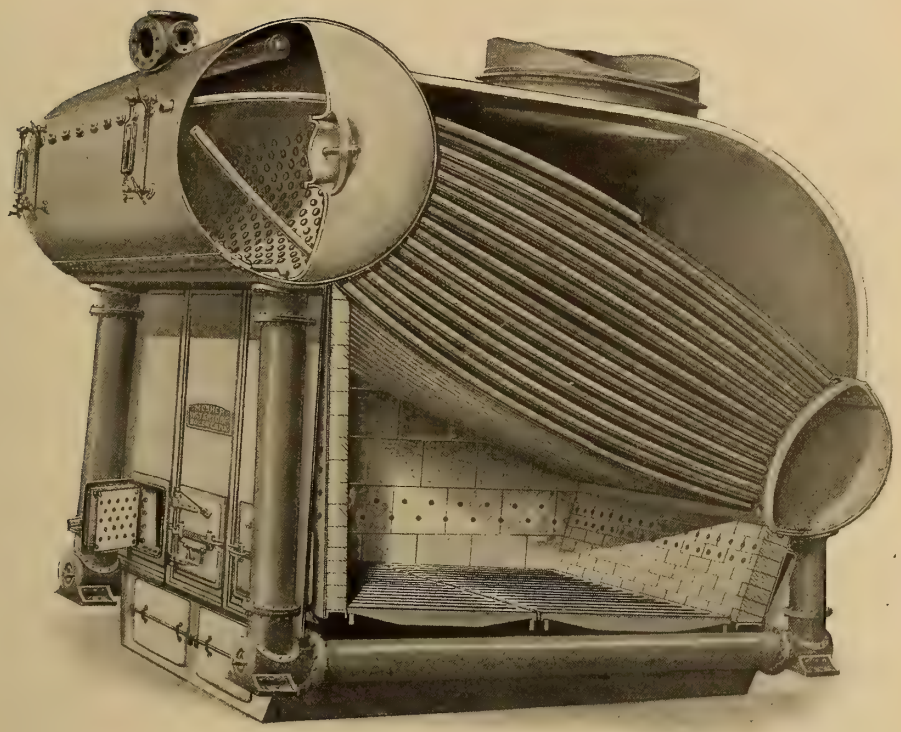


SECTION OF A YARROW WATER-TUBE BOILER

bodies the same features of construction as the cross-type, with the exception that the second row of semi-horizontal tubes is omitted, in order to admit of the insertion of a suitable arrangement of baffles for conducting the gases over the whole of the tube surfaces. One of these baffles takes the place of the omitted row of tubes, forming a roof over the furnace, upon which the soot falls when brushed from the tubes. The accelerated steam raising power of this type renders it particularly suitable for installation in power generating stations, or other situations in which rapid steam raising power is a necessity. The boiler structure is surrounded by removable wrought-iron casings lined with non-conducting composition, thus obviating the infiltration of air.

To obtain the best results with the Babcock & Wilcox boiler the feed-water should be initially purified to a convenient degree, and the water within the boiler should be blown down several inches twice each day.

The mud-drum should be frequently cleaned, generally every fort-



MOSHER WATER-TUBE BOILER, SHOWING METHOD OF REMOVING TUBES
MOSHER WATER-TUBE BOILER COMPANY, NEW YORK

night, or, if the boiler is heavily worked, each week-end. The tube surfaces should be kept free from soot by the frequent and regular application of the steam jet through the side cleaning doors specially provided for this purpose.

The baffle walls which direct the gases in their proper course perpendicular to the run of the tubes should be kept gastight, and the bridge walls should also be maintained in good condition.

The Stirling boiler consists of three steam and water drums and one mud-drum, the upper drums being connected to the mud-drum by three banks of tubes, which are curved slightly so as to enter the drums normal to their periphery. The curvature of the tubes also provides ample allowance for the free and independent expansion of each individual tube. The central steam drum, from which the steam is drawn, is fixed at a slightly higher level than the front and rear drums, thus providing a larger steam space and assisting the output of dry steam. It is worthy of remark that the steam produced by the Stirling boiler is, as a general rule, exceptionaly dry, rarely containing more than $2\frac{1}{2}$ per cent. of free moisture, and this without the aid of antiprining pipes or other steam drying appliances. The general arrangement of the Stirling boiler, and the direction of the convection currents in the front and central banks of tubes, are favourable to the output of dry steam. The steam spaces of the upper drums are connected together by curved steam pipes, the pressure in all three drums being thereby maintained equal. The front and middle drums are also connected by drowned water circulating tubes,

but the rear drum, at which the feed-water enters, has no water communication with the other two, except through the mud-drum, the object of this arrangement being to ensure that the water shall first pass through the mud-drum for the deposition of its impurities consequent upon its having been heated to a temperature of about 325 degrees F. during its passage down the rear bank of tubes before reaching the front of the

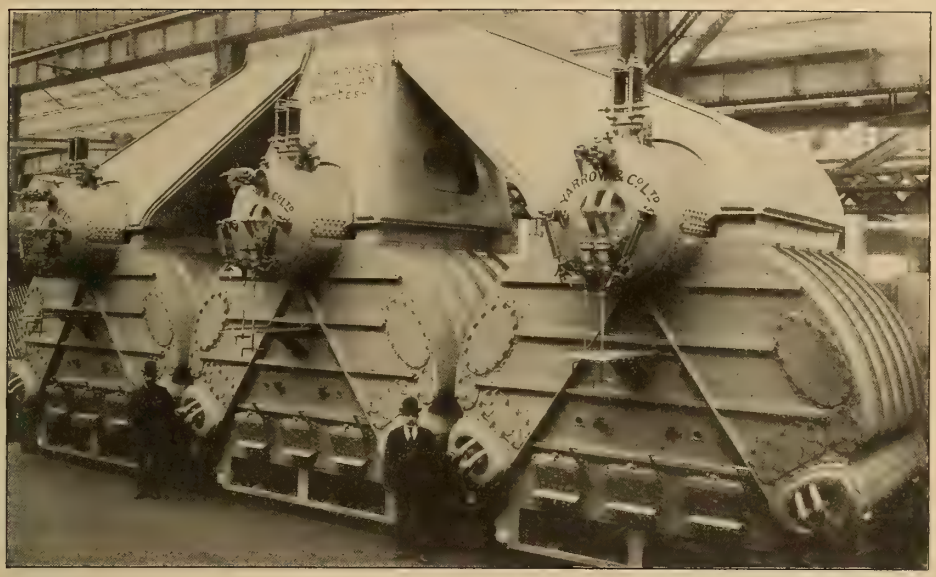
FRANKLIN WATER-TUBE BOILERS UNDER ERECTION AT WEST ALBANY FOR THE NEW YORK CENTRAL RAILROAD. FRANKLIN BOILER WORKS COMPANY, TROY, NEW YORK

boiler, and also to give a definite circulation to the front and middle banks of tubes, the former acting as up-comers and the latter as down-comers.

A special feature of the Stirling boiler is that a firebrick arch is sprung over each grate, immediately in front of the first bank of tubes. This arch absorbs heat from the fire on the grate, becoming an incandescent heat-radiating surface, similar to the roof of a reverberatory furnace, and ignites the fresh fuel as it is supplied to the fire, at the same time supplying the necessary heat for the combustion of the evolved hydrocarbons, thus considerably minimizing the emission of smoke. These arches also heat to a high temperature any air which may be admitted consequent upon the opening of the furnace doors for firing, thereby preserving the tubes from strains due to the inrush of cold air. There are generally four fire grates to the Stirling boiler, each grate having its own firebrick arch. These arches, whilst productive of excellent advantages, are comparatively expensive in upkeep; in some cases they have been taken out and the boiler worked without them on this account.

The course of the heated gases through the tubes is long and circuitous, the heat absorption being consequently highly efficient. Approximately about 73 per cent. of the evaporation takes place in the front bank of tubes.

The rear bank of tubes acts to some extent as a feed-water purifier, thus enabling the boiler to be worked with comparatively dirty feed-water, and dispensing with the necessity of



YARROW WATER-TUBE BOILERS FOR CHILIAN BATTLESHIPS, NOW THE BRITISH WARSHIPS "SWIFTSURE" AND "TRIUMPH"

initial purification of the water. If dirty water is used special attention should be given to the blowing down, which should be performed at least twice each day, preferably after the boiler has rested for a short time. In the absence of continuous feeding, the boiler should be fed with small quantities of water at frequent intervals. The mud-drum and rear bank of tubes should be cleaned at intervals of two weeks in the case of the former and four to six weeks in the case of the latter, except when the feed-water is comparatively clean, in which case the periods of cleaning may be prolonged. The remainder of the boiler requires very little cleaning.

The Yarrow boiler is of the small, straight-tube, express-circulation type, the tubes being generally about an inch in diameter, and inclined so as to make an angle of 60 degrees with each other. The circulation of the water, which is more rapid than in any other type of boiler, arranges itself in each bank of tubes, the inner tubes acting as up-comers and the outer ones as down-comers. No allowance is made for expansion and contraction of the tubes, this being unnecessary, as, owing to the extreme rapidity of the water circulation, the tubes are always at practically the same temperature as the water within them, and consequently expand and contract uniformly with the whole boiler structure.

A comparative disadvantage of the Yarrow boiler is that it is sometimes necessary to remove three or four good tubes to obtain access to one defective tube. For instance, if the nest was twelve tubes deep, it would be necessary to remove five good tubes to obtain access to the centre tubes. A much simpler way of temporarily dealing with defective tubes is to plug them up at each end with cast-iron plugs. If the plugs are properly put in there is no danger of their coming out. This method might be adopted until about 10 per cent. of the heating surface has been so cut off by which time it may be advisable to retube the boiler. Generally speaking, however, defective tubes should be replaced at the earliest convenient opportunity as the process

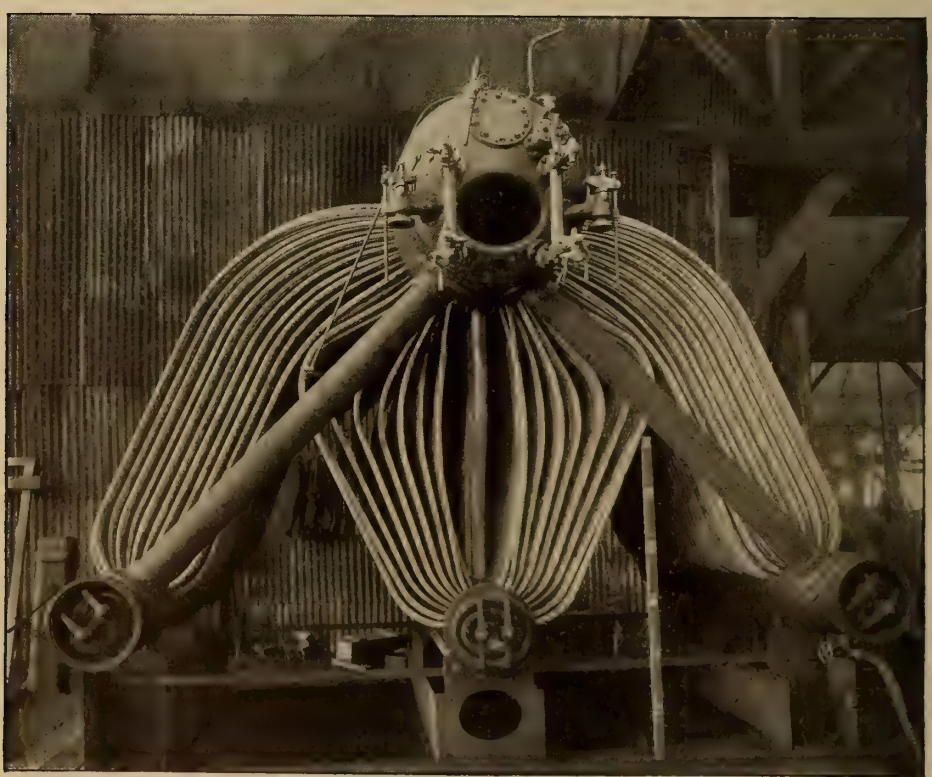
of removing and replacing the tubes is not a long one and presents no special diculties.

The operation can be performed in the stokehold without shifting the boiler. The average life of the tubes is about seven years by which time they appear to wear out simultaneously although they not infrequently go through ten years' service. In naval practice they are usually removed after serving through two sea-going commissions of three years each.

In the smaller sizes of the Yarrow boiler the water chambers are of a semi-circular, flat-topped shape, the cover being formed by the tube plate, which is secured to the chamber by strong, closely pitched bolts. In the larger sizes the water chambers are riveted throughout, and are sufficiently large for a man to enter for cleaning or tube renewing.

Hitherto the Yarrow boiler has been fired at one end only; recently, however, a double-ended type has been introduced, which is fired at each end, thus dispensing with the firebrick wall, and plate and asbestos casing, which is necessary at the back of the single-ended boiler. A saving in weight is thus effected, and the constant repair incidental to firebrick surfaces obviated.

Primarily introduced for installation on board torpedo-boats, the Yarrow boiler proved to be so decided an advance upon the modified locomotive type previously used for these boats that its installation in larger units in cruisers and battleships followed as a natural sequence. It operates to decided advantage in the closed stokehold of torpedo-boats and torpedo-boat destroyers with an air pressure as low as 2 inches of water. It will stand any amount of



THORNYCROFT-SCHULZ WATER-TUBE BOILER

FOUR 125-H. P FRANKLIN WATER-TUBE BOILERS UNDER ERECTION. FRANKLIN BOILER WORKS COMPANY, TROY, NEW YORK

forcing; in fact, it can be forced with impunity for long periods without sustaining appreciable injury.

The Yarrow boiler has, so far, been adapted to land practice to a somewhat limited extent, although with successful results. With the use of larger tubes of from 2 to 2½ inches diameter, which may be taken as a medium size of tube for stationary water-tube boilers, there is no reason why it should not be efficiently adapted to land practice. The increased diameter of the tubes would, of course, lessen the rapid steam-raising qualities of the boiler to some extent; but, on the other hand, there would be much less risk of the tubes becoming choked. The degree of efficiency to be attained would naturally depend upon the degree of cleanliness in which the tubes were kept. The internal cleaning of the tubes is a comparatively simple matter, only requiring the application of a stiff-handled wire brush, the use of turbine or pneumatic cleaners being unnecessary unless incrustation is allowed to accumulate.

Of the Thornycroft boiler there are several types, of which the chief are the "Speedy," "Daring," and "Thornycroft - Schulz." The Speedy type, which derives its name from the torpedo gunboat *Speedy,* on which it was first introduced, consists of an upper steam and water drum connected to two lower water barrels by two groups of curved generating tubes, usually about an inch in diameter. The Daring type, which was designed with the object of securing larger grate surface than in the Speedy type, was first introduced on the British torpedo-boat destroyer *Daring.* It consists of two parallel drums one about the other, the upper being the steam drum and the lower

the water drum. These are connected by several slightly curved 4-inch downstroke tubes, and also by small curved generating tubes. A fire grate is arranged on either side of the lower barrel, being bounded on the outside by small wing barrels, connected by curved generating tubes to the steam drum and by horizontal tubes to the water drum. Originally all the generating tubes were of the undrowned, or overwater type, delivering their contents into the steam drum well above the water level, the downward flow taking place, in the Speedy boiler, through two large outside downpipes connecting the water space of the upper drum with the lower barrels, and in the Daring type through the curved 4-inch downstroke tubes previously referred to. Modern examples of these boilers, however, are fitted with both drowned and undrowned generating tubes.

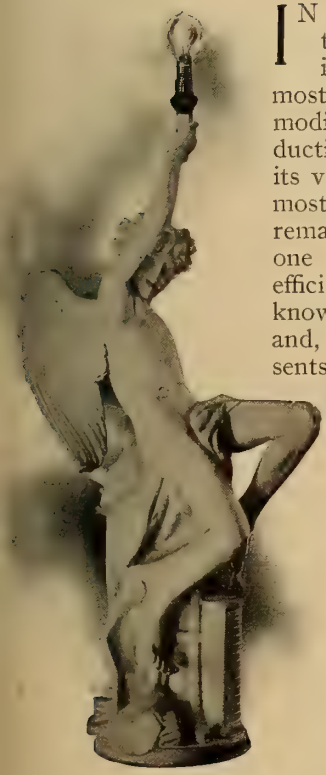
The Thornycroft-Schulz type is in effect an enlarged Daring boiler, the wing barrels being much increased in size and fitted with outside downpipes, the horizontal cross pipes to the central barrel being dispensed with.

The generating tubes are bounded and the furnace gases directed in their proper course by water-tube walls, formed by bringing the two outer rows of each group of tubes together so as to follow the same curves in a transverse section of the boiler, except at the upper and lower ends, where they are necessarily splayed, in order to enter the drum. This splaying is prolonged where necessary, to give the requisite area for the passage of the gases, which, after thoroughly mingling among the tubes, are taken off at the top of the boiler. The curved tubes of the Thornycroft boilers are not ideally efficient in negotiating dirty water, such as sea water, should this become necessary in the event of a leaky condenser or failure of the auxiliary supply; on the other hand, the excessive curvature renders the ratio of heating surface to grate area so large that defective tubes can be plugged with but little detriment to the efficiency of the boiler.

It would far exceed the space at disposal to attempt to deal even briefly with each of the representative types of modern steam boilers, among which, in addition to those already described, may be named the "Niclausse" and the "Durr," both of which are of the Field water-tube type; the "Hornsby" water-tube boiler the "Galloway" water-tube boiler, which is similar to the Babcock & Wilcox boiler, with the exception that the rear and front headers are of different construction; the "Cochran" vertical boiler, and the recently introduced "Scialpi" boiler, which is of the firetube type, consisting of an upper steam and water drum connected to four semi-horizontal water drums fitted with fire tubes and a stayed water chamber surrounding the furnace. Enough has already been said, however, to demonstrate that there are available excellent steam generators of high-grade construction and of sufficiently varied types to fulfill that most important essential to efficiency:—that the steam plant shall be of the type capable of operating most efficiently under the particular conditions of working.

THE PROBLEM OF ILLUMINATION

By Joseph H. Hart, Ph. D.



IN spite of the fact that artificial light is to-day one of the most common of commodities, and its production in some one of its various phases is almost universal, the fact remains that it is to-day one of the most inefficient processes known to engineering, and, in addition, presents a field for investigation and research practically unexplored and among the most difficult and tortuous for further advance. While artificial light can be readily produced, the nature of the thing itself is such as to render its production simple, but at the same time very inefficient according to modern methods. Again, to the majority of illuminating engineers practically no distinction is drawn between the production of light and the problem of illumination, and these are entirely two different problems, involving different conditions and employing different standards. Thus, light can be produced in large quantities with extremely small illuminating power and the opposite conditions may readily hold. In order to understand the relations between these two subjects, a consideration of the problems involved in the production of light itself will be considered, and then the problem known as illumination will be treated.

The nature of light is well known. Its production involves the use of energy. It is a transverse wave in the ether. The comparative size of these waves and the nature of the ether, and its other physical properties, render its handling by ordinary mechanical means extremely difficult; and this is the fundamental difficulty underlying the problem. These transverse waves are, as far as we know, almost analogous to water waves as observed in the ocean. The only apparent change is that these waves do not travel on a surface. They are almost analogous to water waves under the surface of the water. Of course, we know now that light is some form of electrical energy or a magnetic manifestation in the ether, or both, but this does not help us to any great extent in our management of the ether and our production of light. We would encounter the same difficulty with water in its utilization in hydraulic press-work, and in its other applications, if we had nothing with which to grasp it but instruments as porous as fly screens. This is the situation in regard to the ether. Ether travels through ordinary matter very much as the wind does through trees. It takes a very rapid motion of the molecules themselves to produce a disturbance in the ether. Thus, light is in nearly every case produced by the vibrations, or oscillations, of the molecules in the ether. This brings us at once to a subject of which little is known. The nature of the molecules themselves is hidden, and it is

almost impossible to control the motion and behaviour of individual molecules. Thus, the problem of light production is a problem of the control of all the motion of the individual molecule in any substance.

It can be said, off hand, that this has never been accomplished directly. It is accomplished indirectly, but with a loss in efficiency from a mechanical viewpoint that is appalling. Thus, we can drop a heavy block of lead several hundred feet and when it strikes, a portion of the energy is transformed into sound, but the proportionate amount of energy utilized in this development is a very small per cent. of the whole. We would hold an analogous position in sound production if this were our only method of producing sound and musical notes. The problem is further complicated by the fact that only a very restricted number of waves in the ether are perceptible to the eye. As an illustration of this further complication, it can be assumed that when the rock is dropped, a number of musical notes, or noises, are produced. If we have an ear susceptible only to a small fragmentary portion of the sound which is actually produced, this would be a much closer analogy to the phenomenon of light production.

In order to move the molecules at all, an enormous amount of energy must be given to them. Only a portion of this energy is apparent in the oscillation of the molecule and in the production of the transverse waves in the ether, and only a small proportion of this energy which goes into transverse waves has any effect whatever upon the eye. It is very much as though we should try to play an organ where a large power plant were required to operate it, and, in some cases, a separate plant for the production of each note. This represents the situation almost exactly.

Now, the molecules are moved and set in vibration by almost any of the forms of energy known to man, and the special motion of the molecule required for the production of light can also be produced by almost any form of energy, if the energy is utilized in sufficiently large units and no attention is paid to the efficiency of the process. Thus, light can be produced by heat, chemical action, electricity, magnetism, and, in a large number of cases, by methods involving obscure transformation of energy, such as fluorescence, etc., where the action is not fully understood. There is do doubt that we may ultimately hope for the utilization of some of these more obscure processes in an efficient light production. Such a process occurs in the light produced by the glow-worm and is one of the most efficient processes known to nature, as far as science can determine. At present, however, the light is in every case produced artificially by means of heat, electricity, or chemical combinations. It is not known positively at present whether the chemical combination produces light directly in many of the modern developments, or whether the light is produced as a result of the heat which is set free. Chemical knowledge in this line is practically an unknown quantity and is extremely hard to obtain. Electricity, in all probability, produces light as the result of the heating effect produced almost exclusively. And, hence, at present, the only development worthy of consideration, from a practical point of view, is the production of light by means of heat.

Thus, assuming the heat, however produced, light follows as a direct result, if the heat is sufficiently concentrated, or, what comes to the same thing, the temperature sufficiently high. Thus, heat is known to be identical with the motion of the molecule. This motion can be divided into motion of the molecules as a whole, which may, or may not, produce light, and the motion of the parts of the molecule, which in nearly every case does produce light. The motion of the molecule as a whole

undoubtedly produces motion or waves in the ether, but these are not perceptible to the eye as light. Thus, waves in the ether can be produced of any length. Large waves ranging in length from 30 feet down to one-half a centimeter are known technically as electric waves and are identical, as far as we know, in every respect, to light waves and bear the same analogous relation to each other that a large tidal wave does to the ordinary surf. As the waves get smaller, or, rather, shorter in the distance from crest to crest, they gradually turn into what is known as heat and infra red rays. As the process of shortening continues they become visible and continue visible for about an octave, or until the wave length diminishes one-half. Then they become invisible with increased shortening in length and constitute what is known as ultra violet light, which is invisible, and the shortening continues in this department until the waves are too short and involve too small amounts of energy to measure.

Thus, a molecule acquires kinetic energy from heat. This energy is seldom sufficient to produce a rapid enough motion to in turn produce short enough waves to be visible. It is, generally, by the impact of these molecules with one another, or that extra rapid motions are set up, which produce light waves. Now, the problem in lighting consists in the ability to select suitable molecules, having suitable structure, that they will vibrate readily for the peculiar wave lengths which are visible to the eye, and are recognized as light, and in the production of motion in these molecules so as to get a certain proportionate amount of energy into this peculiar form of energy. It can be readily seen that this problem is at its inception and only a fragment of the amount of knowledge necessary for work in this field has been obtained, although the number of investigators is very great.

This is the problem of light production. It is essentially different from that of illumination. Illumination has to do with the nature of the eye and its various purposes and with the utilization of light, and is almost as complicated a problem as the preceding one, and very little more is known in this field. Thus, we have light of various colors. The different color of light is due to different wave lengths in the ether. Various wave lengths combined give new colors in proportionate amount depending upon the different magnitudes of the waves of various lengths. The problem here is as complicated as the ordinary theory of music. Various colors are known as simple ones. Combinations of various waves are analogous to the musical chords, and the effect on the eye is somewhat similar to the effect of music and various wave combinations upon the ear. Thus, some wave lengths tire the eye with extreme rapidity. They need not necessarily be visible to the eye. Thus, a wood or coal fire gives off ether waves of a length which render them invisible, but which have a distinct effect upon the retina of the eye and tire it and produce the smarting sensation common in such cases. Violet and ultra violet light is the particular wave length for which photographic plates are peculiarly sensitive and their response to this light is at least an hundred fold greater than to red or yellow light. The phenomenon known as white light is a peculiar combination of the various wave lengths or colors in various proportions or amplitudes of the waves. Electric light, as produced, possesses a large excess of ultra violet light in comparison to sunlight. Ordinary gas burners possess a large excess of the longer waves in comparison to the same standard. No artificial light possesses the illuminating effect, or produces the same effect on the eye of the individual, that sunlight does. This brings us to the problem of illumination and the various purposes for which light is used. Thus, for reading close print, one kind of wave length is peculiarly fitted, or a certain

conglomerate combination of waves may be more suitable. But in all the wide range of data for illumination, no artificial light compares in every respect with sunlight. Thus, the problem divides itself into the purposes for which light is used and its possible adaptation in this field, with a possibly greater theoretical range than can be obtained with sunlight. We know to-day some few things in this field. The study of the eye has disclosed the fact that certain portions of the retina are peculiarly sensitive to blue light, and when the light is faint this is the light to which the eye first responds. A large number of other conditions could be tabulated, but their practical aspect at present is not as great as it should be. The consideration of the duty that the light must do, however, is of prime importance in its production. Thus, the mercury vapor light, with its control of the molecules more or less directly, by means of an electrical current, produces wave lengths which have large illuminating power for some purposes, but which is very objectionable for others, on account of the localization of the light within restricted limits in regard to wave lengths.

Photometers, as a measure of illuminating powers, are a considerable disappointment, owing to the fact that they are general in their utilization and are not special in their application to certain duties performed by the lights themselves. The comparison of two lights of radically different colors, if the colors are pronounced, is practically worthless as a standard for illuminating purposes, when made with any type of photometer whatever. The whole field of the production of light and its utilization is in a most chaotic state. Only a small amount of the knowledge necessary for development in this field is at hand, and it will be many years before sufficient knowledge will be obtained for active development to be possible sufficient to place this field of engineering on a basis that compares at all favorably with any other engineering development from an efficiency point of view.

NATIVE METHODS OF MINING AND SMELTING QUICKSILVER ORE IN KWEICHOW, CHINA

By Henry Brelich, A. R. S. M., M. Inst. M. and M.

THE introduction of Chinese labour into South Africa lends interest to the following notes and data collected by the author during his six years' residence in the Province of Kweichow. The notes and data relate to the wages, prices, exchange, coinage, laws and customs used by the natives of Kweichow in quicksilver mining, and will be found of value by mining men, who, in the practice of their profession, may come in contact with the Chinese either in their own country or elsewhere. They have already been published in part in a paper read by the author before the Institution of Mining and Metallurgy, but for this article many additions have been made to them and several of the illustrations are new.

The Wan Shan Chang mines are the principal and most extensively worked deposits of quicksilver in Kweichow, and are representative of the conditions prevailing in other parts of the Province, such as Pachai, Beh Mah Tung, and Wuchuan. They are situated in the Prefecture of Toon-Yen, in the Province of Kweichow, about latitude 27° 30″ and longitude 109° 0″ E., at an altitude of 3000 feet above sea level.

The principal route to the mines is from Shanghai (See Fig. 1), along the Yang-tze-kiang to Shasi (903 miles), which is covered by river steamers, thence by junk along one of the numerous canals, and skirting the northwest corner of the Tung Ting Lake, to the Yuen River, which is followed to Senchi (315 miles). From Senchi, the Mayang River, a tributary of the Yuen, is followed to Toon-Yen (85 miles), thence overland to the mines (21 miles). The journey may be accomplished under favourable conditions in twenty-five days.

The mines can also be reached by continuing the journey from Senchi along the Yuen to Huang Chow (195 miles) and then overland to the mines (13 miles).

The distance of the mines from Shanghai is 1324 miles and 1426 miles, respectively, by these two routes.

The country in the immediate vicinity of the mines forms a nucleus whence several cañons radiate to the east, north, and west. Southward in the direction of the Yuen River, numerous conical hills with rounded tops and steeply inclined sides covered with shrub, and separated by narrow, tortuous, cultivated valleys, form the principal features of the country.

The cañons, whose sides rise vertically above the valley below, are narrow and attain a depth of several hundred feet immediately below the mines. They continue in their respective courses for some distance and then widen abrubtly, their sides which previously clearly defined them becoming more indistinct and finally lost in the sharp ridges into which they merge. Beyond the cañons the country is excessively

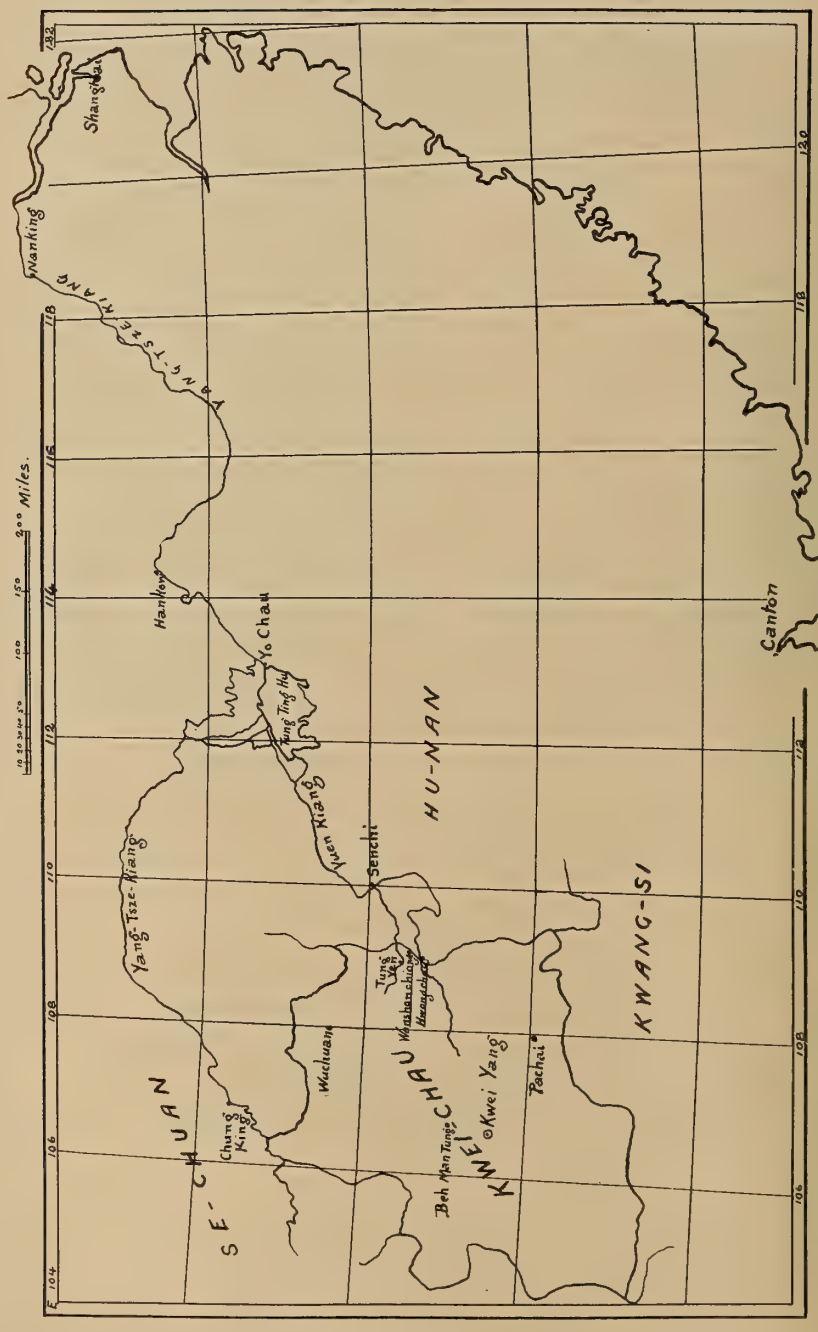


FIG. 1.—MAP OF THE ROUTE TO THE WAN SHAN CHANG QUICKSILVER MINES

mountainous. The woods, almost inaccessible peaks and ridges, present a confused appearance which adds considerably to the scenic effect of the surrounding country.

Caves are numerous throughout this region, and the larger were inhabited by the natives during the incursion by the Miaotze* of this part of the Province. Situated for the most part in almost inaccessible positions, they formed an admirable place of safety and defense. The country is sufficiently watered, thus permitting rice cultivation to be carried on in the highest valleys.

CLIMATE.

The climate, though moist, is fairly healthy, and epidemics which are so prevalent in many parts of China, have never been recorded here. The natives suffer mostly from fever, which is frequently of a more severe type than ordinary malaria. During the rainy season and during the winter months the mortality is highest, due to the carelessness of the people in not protecting themselves against climatic influences, and to the unsanitary conditions of their dwellings and mode of life.

The rainfall and temperature are shown in the following table:

Date.	Average Max. Temp. Degs., Fahr.	Average Min. Temp. Degs., Fahr.	Rainfall Inches.
1901.....	63.33	51.91	57.73
1902.....	66.51	54.84	48.39
1903.....	63.41	52.41	55.70

GEOLOGICAL FEATURES.

The predominating geological formation is magnesian limestone, lying in almost horizontally stratified beds, which attain a thickness of several hundred feet, and extend over a considerable portion of this and the neighbouring Provinces.

The quicksilver deposits are scattered over an area of roughly 3 square miles; they are isolated and irregular in shape, and occupy a distinct zone in the limestone, those near the rim of the cañon being the most extensive and most productive, whilst the numerous smaller ore bodies which occur some distance away from the cañon are, with one or two exceptions, insignificant, and would probably have remained untouched in any other country as too poor for remunerative exploitation.

The ore occurs:

1. Impregnating well defined beds of limestone.

2. Along the joints, cracks, and planes of stratification.

3. In isolated bunches, nests or pockets, and in vughs or cavities, which contain crystalline aggregates or well-developed crystals of cinnabar in the form of penetration twins of two rhombohedra, associated with quartz and calcite.

4. Irregularly disseminated through a number of beds which have, in most cases, undergone considerable local disturbance.

There are two varieties of cinnabar which constitute the ore. One is a bright, transparent red, the other a dark, opaque red, with which antimony is almost invariably associated in small quantities. The former is known as the "red," and the latter as "black" cinnabar. Pyrites are entirely absent. Native mercury is occasionally associated with the antimonial ore. Beautiful twinned rhombohedral crystals are occasionally found, although decidedly rare. Two or three of them, by far the largest in the world, are now in the British Museum.

HISTORICAL

No authentic information can be gathered regarding the time when mining was first begun here. The land owners, who may be regarded as the descendants of the older families, claim that their ancestors carried on mining during the Ming Dynasty (1368-1644 A. D.), but beyond this rather vague statement, no data whatever can be obtained. Chinese history* relates that "Cinnabar is mentioned as one of the articles of tribute

*Aborigines of South and Southern Kweichow, formerly in rebellion against Chinese oppression, but now peaceful.

*Shuking, translation by Legge, Part 3, Book I., Chapter VIII.

from the Kingchou Provinces which formed one of the nine divisions into which the Empire of Yu, 2000 B. C., was divided. This Province included parts of the modern Provinces of Hupeh, Hunan, and Kweichow."

It does not necessarily follow from this that cinnabar was actually mined in Kweichow at that remote period, as the adjoining Province of Hunan is also rich in quicksilver. Nevertheless, when one is confronted by the enormous underground workings, and due regard is taken of the method which was then in vogue for winning the mineral, there can be little doubt that mining in this Province dates from a very early period.

Previous to the introduction of gunpowder by Szechuanese miners some thirty years ago, mining was carried on with the hammer and gad, and in the larger workings by fire setting. This mode of mining, and also the introduction of powder, are well remembered by the old inhabitants. Beyond this change from the previously existing mode of breaking ground, it is probable that no radical alteration has taken place, either in the method of working or in the extraction of the metal from the methods practiced in former times.

POPULATION

The mountainous country surrounding the mines is sparsely populated when compared with the more fertile parts of the river valleys. The number of inhabitants of Wan Shan Chang, within the area where the deposits of ore occur, which includes those in the mining villages and farmsteads, is estimated not to exceed 10,000. In addition to the natives, there is a sprinkling of Hunanese and Szechuanese drawn hither in former times from the adjoining Provinces of Hunan and Szechuan by the reports of rich strikes which were frequently made, and by that element of chance so intimately associated with mining work and so dear to every Chinaman.

The inhabitants may be divided into two distinct classes: mining and agricultural. The former are constantly engaged in mining work and depend for their living solely upon that source, although some at harvest time gave assistance to the farmers. With this exception, they devote their time entirely to underground work or are occupied on the surface near the mines. They work irregular hours of the day or night according to their disposition, and are in no way bound to adhere to any methodical routine of work, which, by the way, is never practiced by the Chinese. Their meals, taken twice a day, consist principally of rice with vegetables, and more seldom pork, washed down by copious draughts of water, which is sometimes replaced by tea. Gambling and opium smoking form their only recreations, and all but a very few indulge in both these,—their favourite and ruinous pastimes.

The conditions underground are extremely bad. The workings are badly ventilated, and the air is made more foul by many of the men who live in the mine, fearing that their ore will be stolen if left without being watched. The oil used in the lamps burns with a lurid smoky flame, and the gases generated by the combustion of the powder on firing remain in the workings and are inhaled by the miners who, as soon as the shot is fired, rush to the face to prevent others from stealing the ore.

Entirely ignorant of the simplest rules to be observed in regard to their bodily welfare, they are thus continually subject to the many injurious influences which surround them, resulting in their being reduced to a most deplorable condition of health. Their most prevalent ailment is disease of the lungs. The stronger and healthier rural population of the surrounding country who work in the fields in a comparatively healthy climate, contrasts markedly with the mining class. The former seldom seek employment in the mines, but during the winter months when there is no demand for their labour in the

fields, they devote a portion of their time to picking ore from the huge mine dumps, both inside and outside the mines.

The "ore pickers," as they are locally termed, are mostly lads, women and children, who, in small gangs, may be seen wending their way to the mines from a distance of 2 or 3 miles at all hours of the morning, armed with basket, hammer, rake,

With this and many similar examples before them in this Province, and probably in other parts of China, it is perhaps not surprising that the Chinese are so averse to mining enterprise being undertaken by foreigners, and in many instances by their own countrymen. They reason that so long as the mineral remains in the earth, they are rich; but if it is removed they derive no benefit

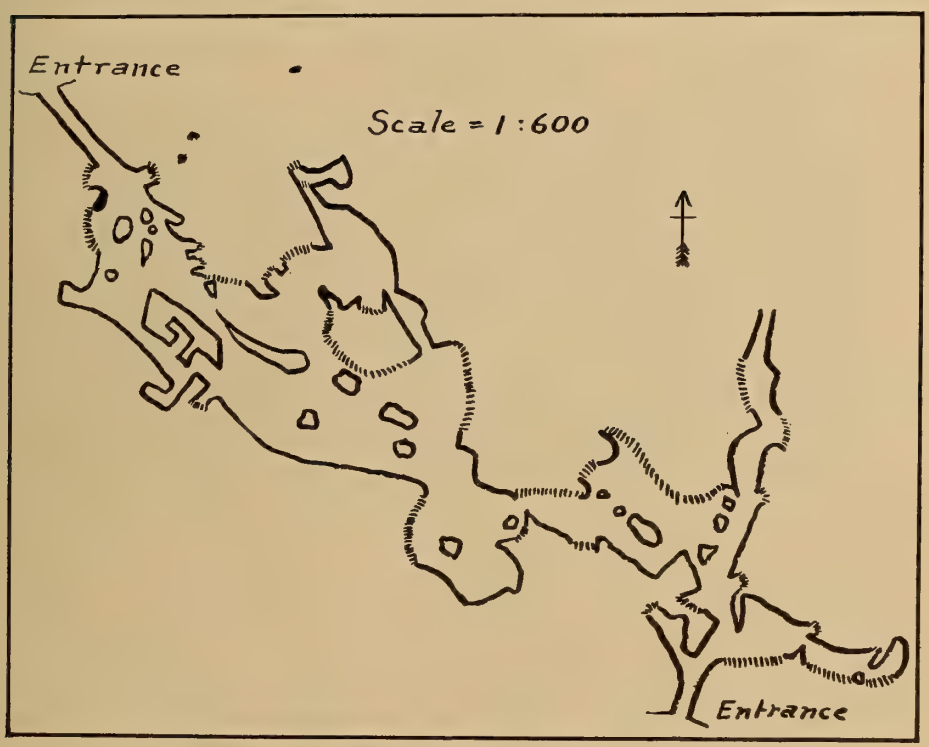


FIG. 2.—PLAN OF AN OLD WORKING AT THE KWEICHOW MINES

and lamp, and returning to their homes in the evening with 10 to 15 pounds of picked ore each, which will assay 1 to 2 per cent. quicksilver. Taken as a whole the inhabitants may be regarded as poor, and notwithstanding the at one time extraordinarily rich deposits of quicksilver which enabled the principals to accumulate comparatively large sums of money, there is at present nothing to indicate the former abundant prosperity of these mines.

from it, and become poor,—a reasoning which is to some extent due to the conditions existing in the interior, where the accumulation of wealth by an individual is seldom productive of any benefit to the community.

"Look at the treasures we shall possess when all the mineral deposits of other parts of the world are exhausted," is an expression often made use of by even intelligent Chinese.

MINING VILLAGES

The mining villages are situated as close to the entrance of the mines as the configuration of the ground will permit. The erection of thatched buildings and the cavern-like entrances, partly natural and partly the result of mining, allow the setting up of numerous huts in which dwell the miners and their families. It is difficult to describe the unsavory spectacle presented by this conglomeration of human beings huddled together within a confined space hardly adequate for the animals which form a part of their household. The concentration of such a mass of people is most probably the result of self-preservation and mutual protection against robbers, who are constantly more or less in evidence.

METHOD OF WORKING

The method adopted for winning the ore is to follow the mineral wherever it occurs, with an entire disregard for the most elementary rules of mining. This naturally results in a series of workings intricate and tortuous beyond description.

The miner follows a stringer or leader or a mineralized band of ore, enlarging the working place only to such an extent as will enable him to work.

In Fig. 2 is shown an old working, said to have been abandoned some sixty years ago, where the ore from an irregularly mineralized bed of limestone 1 foot 6 inches thick has been completely removed by hammer and gad, the working averaging 5 feet 6 inches in height.

Figs. 3, 4, and 6 show, respectively, a mining village, the entrance to a mine, and a group of miners and ore pickers in front of a mine entrance.

Great importance is attached to the stringers or leaders, as previous experience has shown the miners that they are often the forerunners to a deposit of ore. The enormous chambers and cavities which stand in evidence of the former existence of ore bodies were, in the majority of cases, discovered by following these "lines," as they are called by the natives.

The facts that the deposits are not deep seated, and that the deeply carved and fissured country does not permit the accumulation of large quantities of water in the workings, have enabled the natives to carry on mining in their primitive ways without receiving any serious check. During the rainy season the surface water which accumulates in the lower workings is removed by means of bamboo or wooden chain pumps similar to those used for irrigation purposes. If the water cannot be coped with, the working is abandoned for the time being, but the work is resumed during the dry season. Timbering is unnecessary, the ground being compact and holding up well even in the largest working.

Foul air, due to the absence of ventilation, is considered of no account, and men are often at work where the smoky flame of the lamp can only be distinguished with difficulty, without aproaching it closely. The men will submit to constant discomfort in preference to executing any work which causes expenditure and is not directly remunerative.

The ore is mined by drilling holes seldom beyond 15 inches deep with $\frac{3}{4}$-inch iron drills having steel points at both ends. The holes are charged with two or three ounces of gunpowder by first inserting the pricker in the hole, and then the powder, which is tamped with an iron rod, the tamping of clay or finely crushed rock, filling the hole almost to the rim. A pointed bar is inserted in the eye of the pricker, which by twisting is loosened and removed. The fuse is inserted in the space left by the pricker, and a conical shaped piece of paper is placed at the end of the fuse which, after being lighted, smoulders and acts as a time fuse until it reaches the powder.

The principal ingredients of the powder,—nitre and sulphur,—are products of the Province, and the explosive is made at the mine under

circumstances which frequently lead to fatal injuries to those preparing it. Owing to the defective mixing of the three ingredients which constitute the gunpowder, and to the inferior quality of the nitre, the explosive force is not great, an average shot breaking, roughly, 100 to 200 pounds of rock.

The mines may be classed as "private" mines, acquired and worked

FIG 3.—A MINING VILLAGE. ENTRANCE TO A MINE ON THE LEFT

by so-called private companies, and "public" mines worked by individual miners. In the private or company's mines the men are employed either on day's wages or on tribute.

In the first case the miners have to sharpen their own drills before going into the mine, and drill and fire two holes, each about 15 inches deep, this being considered a day's work. They drill single-handed with hammers weighing 6 to 7 pounds, one backhole counting as being equal to two downholes, whilst uppers they are unable to drill. The men work on an average five to six hours per day, but no work is done on every fifth day, which is market day and also pay day, when they receive 400 cash (about 1s.) in addition to the two meals, costing 50 cash (1.6d.), with which they are supplied daily. Overtime is paid for at the rate of 40 cash (1.2d.) for each hole drilled in excess of two. Thus, a miner working on day's pay, earns, inclusive of his food, 130 cash (4.2d.) per day, and works, at the most, twenty-four hours in five days.

When working on tribute, the company assigns a portion of the mine to one or more men, who supply their own tools, explosives, etc., and are allowed to work without any restrictions, on the understanding, however, that the ore mined is to be retorted in the furnaces of the company, who retain a certain percentage of the quicksilver (*i. e.*, the amount collected in the annular space of the furnace through the percentage holes, to be described later), and purchase the mercury produced at a stipulated figure lower than the market price.

The percentage holes are so arranged in the different furnaces that the amount of quicksilver collected varies from 20 per cent. in the case of poor ores to 40 per cent. in the case of rich ores.

The company pays all the taxes to the officials and landowners in whichever way the mine may be worked.

The public mines are mostly old workings which have been abandoned

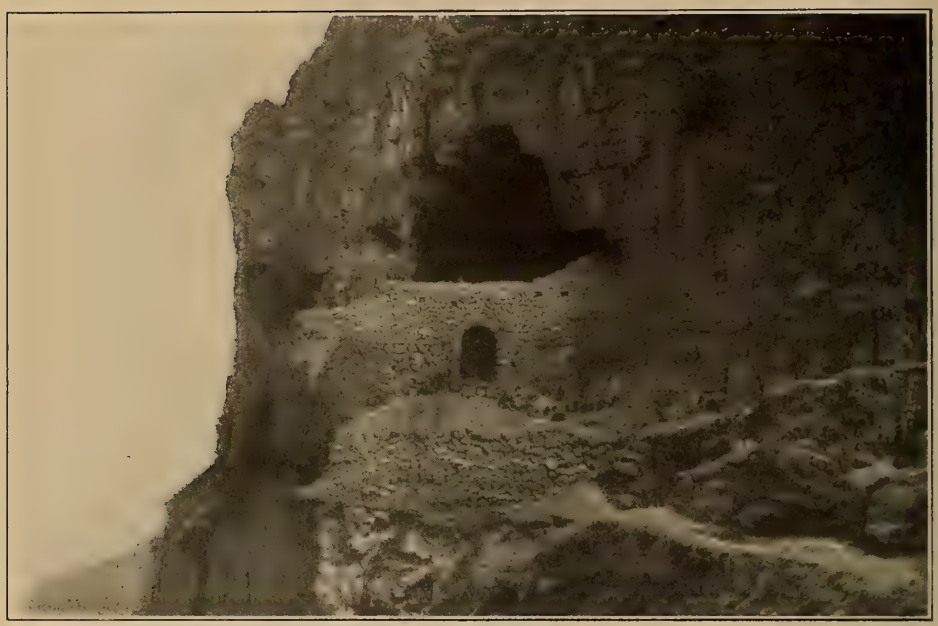


FIG. 4.—ENTRANCE TO A MINE 250 FEET ABOVE BOTTOM OF CANON

as too poor to be worked by a company, but still rich enough for individual miners, who, on payment of a "hammer" tax of 600 cash (1s. 7d.) per month to the local magistrate, are allowed to work in any unoccupied mines within a limit, vaguely defined, "of 10 feet." If the ore is won in sufficient quantities, the landowner establishes a furnace near the mine and the miner is compelled to have his ore treated in it, the owner retaining the usual percentage collected through the percentage holes, which is seldom, if ever, below 20 per cent.

TREATMENT OF THE ORE

The ore is sorted in the mine and brought to the surface in bamboo baskets of a capacity of 30 to 40 pounds, fastened on the back of the carrier by ropes which pass under the armpits. It is then cobbed and picked, and as much as possible of the barren rock is removed. Then, after detaching any large crystals of cinnabar with a pointed piece of stout wire, the ore is crushed to pass a $\frac{1}{8}$-inch bamboo sieve, and if the cinnabar is of the red variety the crushed ore is panned and the clean cinnabar (concentrate) removed. The tailings are treated for quicksilver in the retort furnaces.

The ore containing the "black" mineral is similarly crushed and treated direct for the metal, without any previous panning.

The circular retort furnaces, Fig. 5, in which the ore is treated, are built in pairs 2 feet 6 inches in diameter and 1 foot 6 inches high. They consist of an ordinary cooking pan, which serves as a receptacle for the ore, resting on a round fireplace built of unburned bricks, above which is placed an inverted pan having a hole in the centre 12 inches in diameter. On the top of this is built a collar of clay 12 inches high, strengthened on the outside by a plaited network of bamboo, which extends a few inches above the clay collar and serves as a support for the topmost pan. The top of the collar is grooved in the center, and resting on its inner rim

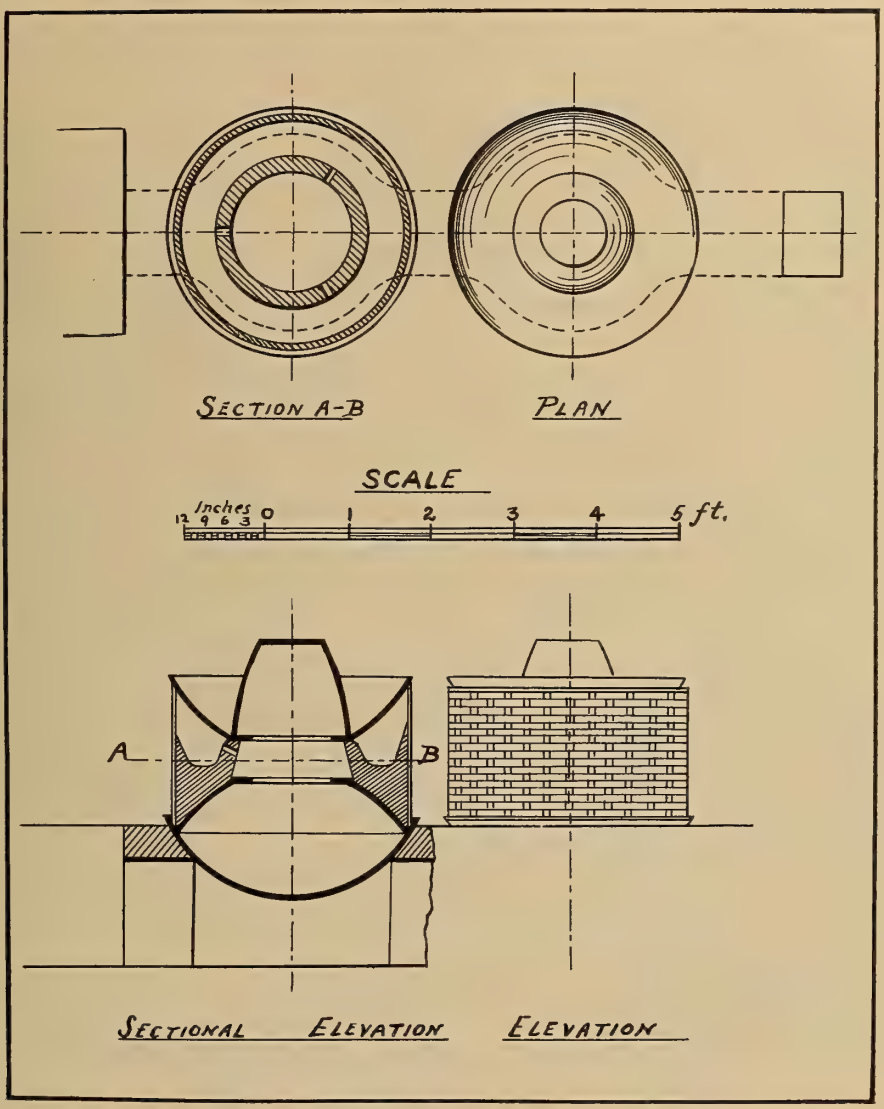


FIG. 5.—CHINESE MERCURY FURNACE

is another pan with a 12-inch diameter hole, covered by an earthenware pot which, when the furnace is in operation, acts as a condenser. An annular space is thus formed between the groove, the lower part of the top pan, and the inner side of the bamboo network. The rim of clay on which this pan rests is perforated with three holes, ¾ inch in diameter, known as the percentage holes, which are inclined towards the center of the furnace, and the amount of quicksilver collected within the annular space depends on the pitch of these holes, increasing as the angle is increased. One of these holes is shown in the sectional elevation, Fig. 5. The earthenware condenser resting on the top pan is luted with residues and the inside of the bamboo network is lined with clay.

About fifty pounds of ore is charged into the lower pan, and

heated with wood fuel, the quicksilver vapours condensing in the annular space and the earthenware pot, which is changed at intervals until the ore is exhausted, when the residues are withdrawn by means of a shovel with a blade at right angles to the handle, and replaced by another charge. The residues, especially in the case of rich ores, which still contain imperfectly burned ore, are ground, sluiced, and the concentrate again retorted. Whilst the condenser is being changed, the ore in the pan is stirred with a wooden pole and copious fumes escape through the opening. During the operation the condenser becomes coated with numerous minute globules of quicksilver, which, after its removal, are run together by rubbing the surface with a rag, and form in a pool at the bottom of the pot. The losses, as far as can be estimated, vary between 30 and 40 per cent. of the total quicksilver.

When treating rich ores, about 1 catty (1 1-3 pounds) of quicksilver is collected in each clean-up from one of the earthenware condensers. The metal is poured into bamboo flasks and transported to the river port in pigs' bladders.

The following data regarding the working of these furnaces were obtained from a native smelter treating tailings, where four furnaces (eight retorts) are in constant operation:—

Number of men employed per 24 hours = 3. The men work at the furnace only 24 hours every four or five days to avoid becoming salivated.

Wages per 24 hours = 1200 cash, say 1s. per man, or a total of 3s.

Total average amount of ore treated per 24 hours = 3000 catties (4000 pounds).

Each furnace is charged per 24 hours = 7 to 8 times.

Average yield, including final recovery when furnace is pulled down, per 24 hours = 8 catties (10.7 pounds).

Cost of fuel, per 24 hours = 3200 cash (about 8s. 6d.).

The cost of one furnace (two retorts) complete, is 4000 cash, say 10s. 9d., lasting about one month, during which time it is constantly undergoing repairs.

In addition to the furnaces at work near the mines, a considerable number are owned by individuals who carry on custom smelting, receiving in payment the quicksilver collected in the annular space through the percentage holes. The ore treated in these furnaces is obtained either from the mines, or from the dumps, and frequently by theft. These custom furnaces, producing singly a comparatively insignificant amount of quicksilver, are nevertheless important factors in the production of the metal, as a large percentage of the total output is derived from these numerous sources.

The owners of private mines have a set of furnaces for rich ore, and one for poor ore, and, if the miner strikes a rich pocket, the ore is treated in the rich-ore furnace, whose percentage holes are so inclined that the furnace owner receives about 40 per cent. of the total distillate as his share. This is an established custom to which the miners willingly conform.

STORES AND SUPPLIES

All the necessary stores and supplies required by the miners in connection with their work are produced and manufactured in the province, with the exception of wick, which is imported from the Province of Szechuan.

The following is the cost of the principal articles which may be procured locally:—

	s.	d.	
Wrought iron	0	1.4	per lb.
Steel	0	2.1	per lb.
Sulphur	0	1.7	per lb.
Nitre	0	4.3	per lb.
Charcoal	0	10.2	per 100 lbs.
Oil	0	1.6	per lb.
Wick	0	6.8	per lb.
Firewood	8	6.4	per cord 5 ft. × 5 ft. × 5 ft.
Ore baskets	0	1.4	each.
Wrought iron lamps	0	3.8	each.
Cast iron pans, used throughout China for cooking purposes	2	8	each.
Wooden pans	1	7	each.

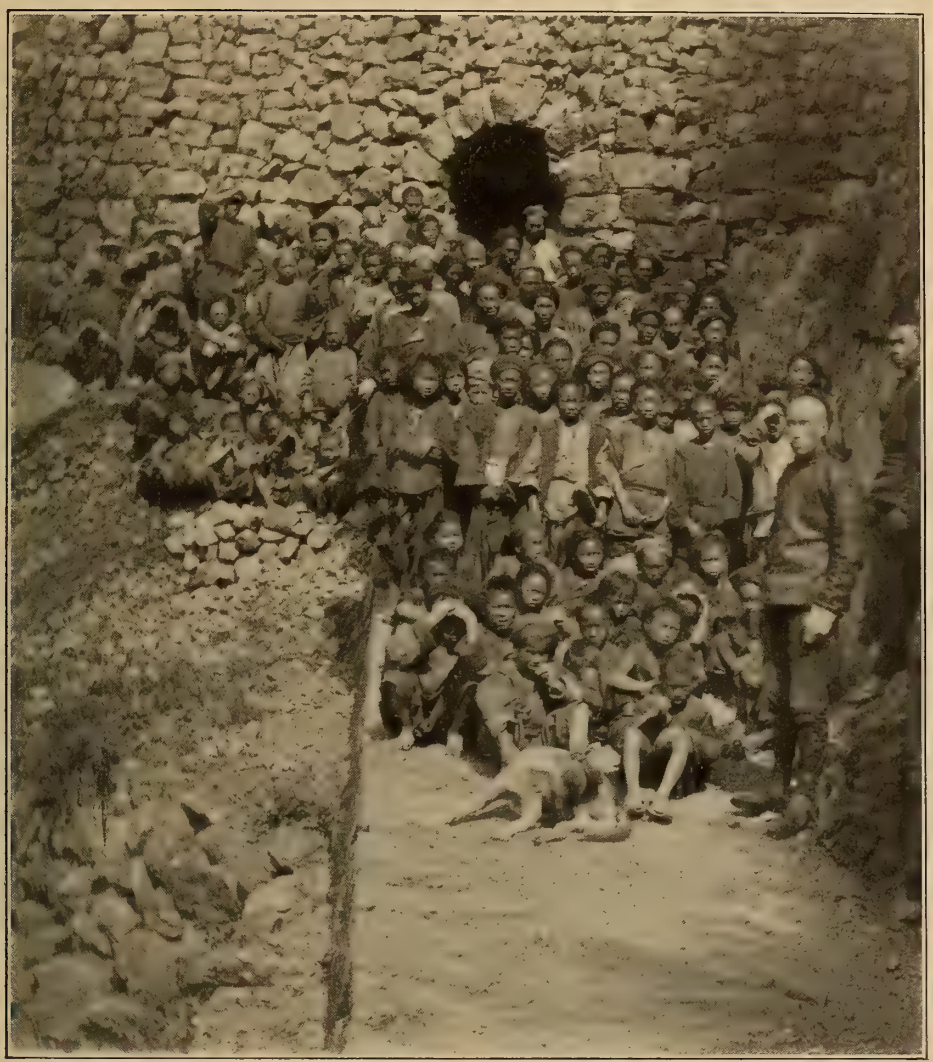


FIG. 6.—GROUP OF CHINESE MINERS AND ORE PICCERS

MINING LAWS AND TAXES

Mining laws are practically unknown, and, although, of recent years, mining regulations have been issued by the Imperial Government, they have not been enforced, and the natives are ignorant of their existence. The Government owns no land in the neighborhood of Wan Shan Chang, which is the ancestral property of two or three families and their numerous progenies.

A Chinese land owner possesses all surface and mining rights within his boundary; consequently any mining carried on in his property entitles him to the receipt of a small tax, which is paid either in cash or kind by the miner. In addition to this tax there are numerous other arbitrary taxes or "squeezes" levied by the officials under whose jurisdiction the mines are situated.

The produce of the mines is indirectly taxed through the "ching fu" or weighers, who are the principal

merchants of Wan Shan Chang, and to whom, on payment of a monthly tax to the prefect, is given the sole right of purchasing all the quicksilver and cinnabar produced, with the exception of that which is produced from those mines where the owner pays a tax direct to the officials, and is thus exempted from selling the produce to the weighers.

The price paid by the weighers is somewhat lower than the prevailing market price, usually about 100 cash (3.2d.) less per catty, but this deduction is either increased or decreased according to the demands of the market.

The term "squeeze" should logically be confined to the illegal detention or extortion of money. Thus, an official has a right to levy a certain tax in granting rights to work a mine or open a shop, and such rights are usually granted to one who will pay an additional 20 per cent. or 30 per cent. as a bribe. The legal and just tax levied by an official is, however, commonly called a squeeze. The author estimates that, notwithstanding all taxes and squeezes, the output of a mine worked by the natives is taxed only to the extent of about 2 per cent. on its net value.

WEIGHTS, MEASURES, AND CURRENCY

There is no standard for the weights and measures in use, and there is considerable variation in these throughout the Province. The catty (1 1-3 pounds) is the representative weight and may be regarded as being fairly uniform throughout China, whereas, the picul "dahn," which should be equal to 100 catties, is not a fixed quantity and when mentioned in a transaction it is always advisable to inquire "of how many catties."

Quicksilver in quantities above 5 catties, is sold by measure, and not by weight. The measure used is made of brass and is shaped like a truncated cone, 5 inches high, 3 inches in diameter at the base, and 1¼ inches in diameter at the top; it holds 5 catties when full.

The foot, ch'e, is the measure used by the miner, and is equal to about 15 inches; this divided into 10 inches "che'n," and this again divided into tenths "fun." Measurements equal to, or exceeding 10 "ch'e" are referred to as so many "chang," one chang being equal to 10 feet.

The only coin in circulation is the cash "chien,"* a circular disc, differing in size and weight, made of copper or brass, with a square hole in its centre. It is threaded on a string up to one thousand, nominally, but actually to 960 to 980, which in cash equals 2s. 7d., and in weight 6.2 pounds. Silver ingots called "uen bae,"† of varying weight and fineness are also in use, and they are exchanged for cash at a certain rate per ounce "leeang"‡ of silver, which is dependent upon the fineness of the silver, the quantity and size of the cash, and upon the cash reserve in the hands of the merchant bankers. Notes of 1000 cash face value issued by the bankers are also in local circulation.

As regards currency, the rate of exchange constantly varies. There is no such coin as the "tael" which is merely a name for an ounce of silver. The term is only used in the treaty ports and is unknown in the interior where the value of an article is always stated as being equal to so many ounces or "leeang" of silver, which varies in every town. The exchange for an ounce of silver is also variable, and, is now, roughly speaking, 1000 cash equals 1 Kweiyang tael, but the author has known it as high at 1400 cash.

For the purposes of this article the following rate of exchange is taken:

1 Shanghai tael = 2s. 6d.
£1 Sterling = 8 Shanghai taels.
1 Kweiyany tael = 2s. 8d.
= 1.000 cash.
= 1.166 ozs. Troy, of silver.
= 1.065 Shanghai taels.
1 penny = 31.2 cash.

---

* "Dien chien." Good cash about 1 inch in diameter. "Mao chien." Bad cash about ⅝ inch in diameter.
† Called svee in the treaty ports.
‡ Called tael in the treaty ports.

The Kweiyang tael has been taken in this article because it represents the tael as used in the Provincial capital of Kweiyang.

PRODUCTION

No data are available concerning the former output of these mines, hence no attempt at any estimate can possibly be made. It is stated that thirty years ago the output amounted to 7000 catties (9300 pounds) of cinnabar and 3000 catties (4000 pounds) of quicksilver per month, and to have been maintained at these rates for a number of years, when the production of quicksilver increased and the output of cinnabar diminished.

During the last few years the output has averaged 3000 catties (4000 pounds) of quicksilver per month, while the cinnabar output has been constantly decreasing and now averages about 200 catties (270 pounds) per month from native sources only.

The metal is exported from Toon-Yen, either in pigs' bladders or iron flasks, to other parts of China, where it is used for the manufacture of vermillion, for which there is a great demand throughout the Chinese Empire.

In the following table the price of quicksilver at the mines is compared with the London quotations at the corresponding period, per flask of 75 pounds:—

Year.	London Average Price per Flask of 75 Lbs.	Mines Average Price per Flask of 75 Lbs.
	£ s. d.	£ s. d.
1901.....	9 2 6	6 2 11
1902.....	8 15 0	7 19 3
1903.....	8 12 6	7 17 11
January to July, 1904.....	8 0 0	7 1 7

The large cinnabar crystals detached from the ore, and the red cinnabar extracted by panning previous to the ore being treated for the metal, find a ready sale in the local markets. They are usually solid in packets of 100 ounces (8.3 pounds), containing varying proportions of fine and coarse cinnabar, at prices ranging from 850 cash to 1300 cash (2s. 3.2d. to 3s. 8.6d.) per catty (1 1-3 pounds), whilst the larger crystals, which are now much rarer, are often sold without any admixture of fine cinnabar up to 5000 cash (13s. 1.2d.) per catty.

CONCLUSIONS

From the meagre information one is able to gather regarding this industry, there is no doubt that the mineral was at one time mined on a very large scale, and that the industry was in a far more flourishing condition, and the output of the metal and cinnabar much greater than it is at present. The extensive underground excavations, which stand as monuments of previous mining activity at the principal localities where the mineral occurs, form conclusive evidence of the work which has been accomplished in former times.

Apart, however, from other quicksilver deposits which may be revealed by further systematic prospecting of the large portion of this Province which is as yet unexplored, the condition of those mines now in operation by the natives is such as to warrant the expectation that a constant output will be maintained for many years to come.

THE LAW OF ECONOMICAL PROPORTION

AS APPLIED TO TRAMWAY ROLLING STOCK

By William R. Bowker

In endeavouring to determine some general rule by which the various types of rolling stock employed on electric railways may be proportioned as to their respective numbers, Mr. Bowker discusses the various conditions of operation in a manner not hitherto commercially applied. While his discussion is mainly taken from a British point of view, the principles are themselves fundamental in their nature, and hence generally applicable, and so of practical interest both in England and in the United States.—The Editor.

THE above "phrase" is employed by the writer to cover the subject dealing with the numerical proportioning of different types and sizes of tramway cars, as used by electric tramway undertakings. The subject is one that demands the most thoughtful consideration from tramway advisers, consulting experts, committees and managers. The writer has never seen any information or suggestions in print, dealing with this subject, and, so far as he is concerned, it is an entirely new one, and the ideas, conditions and discourse are original.

The proposition is a commercial one, and there must be some law connecting the various factors involved, with the ideal and ultimate end in view of attaining a maximum of receipts with a minimum of expenditure.

The article is devoted solely to the proposition as regards the tramway rolling stock.

Experienced electrical engineers are acquainted, or have had some dealings with Lord Kelvin's law relating to capital outlay and current density of metal conductors. This law is represented by a mathematical formula, and the importance of it, both from a financial and practical standpoint, cannot be over estimated. It is the application of scientific and technical principles adapted to a commercial problem with a view to economy.

That such a law can be similarly applied to tramway rolling stock, the writer is fully convinced, and while he deals with it from a theoretical and purely reasoning point of view, the mathematical formula which should involve his theoretical reasoning must be left to abler hands than his. While the mathematical formula treatment of it may not be brought down to such a condition of simplicity as Lord Kelvin's law, for the reasons that more conditions are involved, still, at the same time, a formula might be evolved which would be approximately accurate for all commercial and practical purposes.

The fundamental conditions involved are initial cost per car, power expenses for running same, labour expenses, interest on capital outlay, depreciation, maintenance, and renewals. Reliable data is obtainable on several of the above factors. The initial cost per car depends upon the type of car, whether of the large or small size, single or double deck; if single deck, whether all closed or a combination car (which is open at each end and closed in the central portion, or vice versa). The power utilized in running the car will, of course, depend upon the type and size of the car, nature of gradients, etc. For all types up to the large double-deck cars the labour expenses (viz., motorman and conductor) will be the same. In the case of large double deckers, a car boy or conductor's assistant is absolutely necessary, for the obvious reason that the conductor cannot perform all the duties

necessary when the car is fully laden with passengers during rush hours. He confines his attention to collecting the fares and the boy assistant to starting and stopping the car; also looks after the trolley pole cord; therefore the labour expenses are increased. The interest on capital outlay will vary pro rata in proportion to the initial cost of the car. Depreciation allowed will also vary in proportion. Maintenance costs will vary with the type of car adopted, single-deck cars costing less to maintain than double-deck cars. Renewals will also vary with the type of car.

It is thus seen that the initial cost, labour and power expenses, interest, depreciation, maintenance, renewals, etc., depend upon the type of car adopted.

We have now found out by summarizing the principal conditions, and must now discuss how local and traffic conditions affect the choice of the type of car.

The physical conditions which influence the choice of car, are the nature of gradients and curves; it would obviously be courting commercial disaster to adopt the large type double-deck cars in a town or city where long, and steep gradients existed; for the reason that too much power would be used by the car. Then again it is questionable whether such a car, heavily laden with passengers, would mount a steep and long gradient. Outside of these reasons, there is the element of danger to be considered. Under such physical conditions the most suitable arrangement would be a proportioning of three types of cars, viz., (a) the small type double-deck car for summer use or fine, warm days; (b) the single-deck all-closed type; (c) the combination single-deck car. This latter type of car generally caters to all of the requirements demanded by a traveling public. A good proportion from a British standpoint would be in the ratio of 2, 1, 2, respectively.

Dealing with local passenger traffic conditions, we may for convenience divide this into two headings, viz., one in which the passenger traffic varies greatly in amount at different hours of the day, i. e., a period of heavy passenger traffic demand, involving rush hours, and a period of comparatively small traffic demand. Such a typical case exists in the case of large business or in manufacturing centres, the outskirts of which are residential. The artisans and work people would travel in great numbers at certain rush hours of the day. Assuming that these hours were: morning, 6:30 to 9; noon, 12 to 1.30, and evening, 5:30 to 7, this will total up to about $5\frac{1}{2}$ to 6 hours, or one-third of a traffic day of approximately 18 hours; viz., from 6 A. M. to 12 midnight.

During these rush hours in fine weather, the large type double-deck cars could profitably be utilized because they are more economical than the small type of car, pro rata per passenger. Not only are they more economical under the power heading, but also as regards labour expenses, because two large cars will carry approximately as many passengers as three small ones, thus reducing the labour expenses. During the rest of the day, a small type of car would be used, for it is obvious that to run a large car only partially filled with passengers is not economical. These cars would preferably be of the single deck, all closed, or combination type.

Giving full credit to the claims of the double-deck car, at the most it is only a summer car, for when winter and bad weather sets in, the top deck seats become untenable and the car carries only a portion of its full complement of passengers. They then, to a great extent, become unprofitable, or at least not as profitable as they might be, which, from a commercial point of view, is disadvantageous. Owing to the gross error in judgment made by tramway undertakings by generally adopting them, they soon find by experience that this financial weakness presents itself in no unmistakeable manner. To over-

come the difficulty they have to spend an extra £100 to £150 per car to patch up a bad beginning, by fitting top covers to them. While admitting that the fitting of top covers does increase the passenger traffic receipts during bad weather, there has to be set against this, the auxiliary patching-up cost (£100 to £150), interest on same, increased power expenses, due to increased weight and air resistance, approximating 15 to 20 per cent., maintenance, depreciation, etc., in addition there is generally the disadvantage of bad ventilation and a foul atmosphere; grievances from passengers regarding draughts, and the smoke accumulating therein, etc. A patched-up car with top covers is never entirely satisfactory. The way out of this difficulty is not to adopt top covers at all, but adopt the combination car; it is an all-the-year-round car and approaches the ideal from many standpoints. The advantages which it possesses are, (1) the much shorter space of time in which the car can be emptied and filled, (2) the greater ease with which the conductor can collect the fares, he having no stairway to climb, (3) the greater height which can be allowed in the interior of the car, (4) consequently ventilation is more easily attained, (5) having no stairway they eliminate the danger of accidents to passengers, due to falling, etc., (6) the much lighter construction that can be employed in the roof and car in general, (7) they are more durable, and cost less in maintenance expenses, (8) they are more commercial from every point of view, (9) they are convenient and cater for all classes of passengers, both smokers and non-smokers; people who like fresh-air rides and those who prefer an enclosed car.

In wet and windy weather the open seats can be totally enclosed by means of waterproof blinds. A big propotion of the total number of cars should be of the single deck, (a) enclosed, and (b) combination type.

Taking the case of a large city as under consideration, with moderately level roads (no long or steep gradients) four types of car can be adopted; (a) large type double deck; (b) small type double deck; (c) single deck, all-closed type; (d) simple deck combination, and an economical proportion would be in the ratio of 1, 1, 2, 4, respectively.

Under no circumstances does the writer recommend top-covered cars, nor yet large, double-deck cars on routes with long and steep gradients.

Finally, the second general heading of passenger traffic demands; a typical example would be in the case of a comparatively small town or seaside resort, where there are no rush hours during the day. Under such circumstances no double-deck cars would be advisable, but the single deck wholly closed and single-deck combination cars should be adopted in the proportion of 1 to 2, respectively. These would be all-the-year-round cars and the whole of the cars would be in use in the summer season at a seaside, with a convenient time service, while in winter only about one-half to two-thirds the number of cars would be utilized with a greater interval time service.

When it is realized that each car costs initially from £550 to £600, and that the purchasing of 500 cars involves an initial outlay of approximately £300,000, it is obvious that money can be wisely or foolishly expended, and if undertakings adopt double-deck cars as a whole, such choice is a gross error of judgment, for the reason that when winter comes a big proportion of the cars become non-commercial, and to remedy the error a patching-up expense is involved to the tune of £100 to £150 per car. There is, therefore, in the opinion of the writer, a law of economical proportion by which we attain a maximum commercial benefit with a minimum of total expenditure. By sound judgment, experience, and a foresighted look into the future, a wise provision can, at the outset, be made by a careful study of

the situation and to my mind, it is a simple matter to either save or waste £50,000 on a £300,000 outlay. Whether the proposition can be brought down to a mathematical formula to cover all and every practical and local condition, is for mathematicians to determine. The difficulties in this direction seem to be due to the numerous factors to be taken into account, but there should be a connecting link whereby we attain the most economical result by properly proportioning the types of car so that they are utilized to the fullest advantage by apportioning the initial cost and interest on same, the labour expenses, power expenses, maintenance, depreciation and renewals. The graveness and importance of a thorough and systematic study of this commercial proportion cannot be overestimated. From appearances, it is obvious that British tramway undertakings in general have not studied the proposition on the lines suggested in this article, as is evidenced by the wholesale adoption of the double-deck car of both the large and small type. It is only the experience they are daily gaining which makes them realize the gross error of judgment by their adoption. This is obvious from the fact that nearly every corporation in the country are being forced (for commercial reasons) to adopt the patching-up by means of top covers. They are not being adopted from choice, but because they must have a remedy. In a few words they adopted a summer car pure and simple and then have (at enormous expense, practically 20 per cent. on original cost) to convert it to a winter car. While the British tramway undertakings, with their approximately five years' experience, have almost universally adopted the double-decked type of car, the American and Continental tramway undertakings, with their twenty or more years' experience, have almost universally adopted the single-deck car; they are unanimous in their preference for them and the cars have proved a commercial success. It is obvious to anyone that the combination single-deck car is the one nearest approaching the ideal, it being, to my mind, preferable from every point of view both commercially and as a conveyor of passengers. The writer strongly advocates the more general adoption of the single-deck car, and, in his opinion, under ordinary circumstances one type (and one type only) covers the economic law of proportion, viz., the combination single decked car as described above.

SOME REMARKABLE LOCOMOTIVES OF 1906

By J. F. Gairns

THE locomotive developments of the past few years in all parts of the world have been so remarkable that it is difficult to classify the locomotive practice of 1906. Many of the designs introduced during the last year are developments of previously existing designs that are themselves remarkable, while the actual innovations are few, yet most of them, whether considered as developments or as innovations, are sufficiently noteworthy to be described as "remarkable" locomotives.

Although compounding is by no means in universal favour, particularly in Great Britain, and to some extent in Germany, Belgium and the United States, a large proportion of recent locomotive designs include this feature, when the world's practice is considered, and not that of a particular country, and consequently a considerable number of the locomotives to be described in this article are compound. The general subject of compounding will not, however, be considered except so far as it is necessary in describing the locomotives illustrated, for that subject was dealt with technically in an article by Mr. Lawford H. Fry, which appeared in the January issue of this magazine. To some extent the descriptions of selected locomotives appended to that article are pertinent to the present review of recent locomotive practice, but in most cases the locomotives now to be described are more recent than those then described. Where the locomotives then considered come within the strict purview of this article they will merely be referred to.

Dealing first with a few examples of remarkable British practice, Fig. 1 illustrates a new class of compound express locomotive introduced by Mr. Wilson Worsdell on the North-Eastern Railway. These are developments of the large 4-4-2 non-compound engines in use on that line, but differ therefrom in that a Belpaire fire-box is employed, and the cylinders (compound according to the new Smith system) all operate on to the leading coupled axle. Two of these engines are in service for trial, one of them being fitted with the ordinary link motion, and the other with the Walschaert valve gear, two sets only being employed in each case for actuating the four slide valves. The high steam pressure of 225 pounds per square inch is employed.

The Atlantic type has been introduced on two British railways during the year as an innovation, but its use has been extended on railways already employing locomotives of that type. These are the London, Brighton, and South Coast Railway, where the design employed corresponds very closely with that used on the Great Northern Railway, and the North British Railway, where the engines are very large examples, designed by Mr. W. P. Reid, the locomotive superintendent. Both classes are non-compound, and in the latter case the engines are the first 4-4-2 locomotives introduced by a Scottish railway.

On the Great Western Railway a four-cylinder non-compound locomotive is in service. In this engine two cylinders operate on to separate coupled axles, so that the design is "divided and balanced," and a very

FIG. 1.—SMITH-WORSDELL COMPOUND EXPRESS LOCOMOTIVE. NORTH EASTERN RAILWAY

fair comparison is possible with the French de Glehn compound engines in use on that railway, especially as the dimensions correspond somewhat closely. This locomotive is stated to be so successful that a series of similar engines are to be constructed, some of the 4-4-2 type and others of the 4-6-0 type.

The use of the 4-6-0 type for passenger service has been extended in Great Britain during 1906, but the only new designs are intended more for "mixed traffic" or fast freight service than for express passenger traffic, though such engines are often given fast passenger trains to work.

On the Caledonian Railway large-wheeled express engines of this type (coupled wheels 78 inches diameter) and small-wheeled engines (coupled wheels 60 inches diameter) were already in use; but during the year Mr. J. F. McIntosh introduced an intermediate class having coupled wheels 69 inches in diameter, and one of these engines is shown in line diagram in Fig. 2.

Locomotives of this type with small wheels have been introduced for fast freight traffic on the Great Southern and Western Railway of Ireland, the London & North-Western Railway (non-compound), and the Great Central Railway. One

FIG. 3.—TEN-WHEEL, 4–6–0, EXPRESS ENGINE FOR MIXED TRAFFIC. GREAT SOUTHERN AND WESTERN RAILWAY OF IRELAND

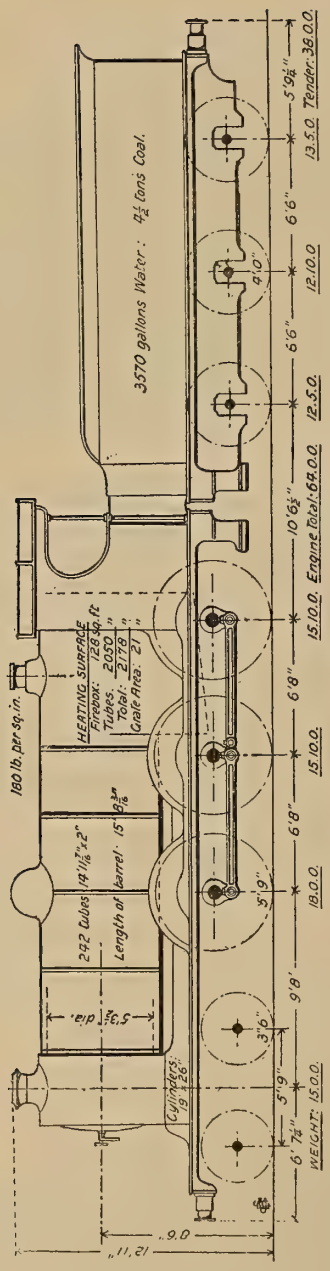


FIG. 2.—NEW 4-6-0 LOCOMOTIVE FOR MIXED TRAFFIC. CALEDONIAN RAILWAY.

of the engines for the former line is shown in Fig. 3, these being the first ten-wheeled tender locomotives employed in Ireland.

No new designs having eight coupled wheels have been introduced during the year, but on the Great Eastern Railway Mr. Holden's remarkable ten-coupled tank engine of 1903 has been converted to this type, and a new design is promised for an early date on the Hull and Barnsley Railway.

New tank engines of remarkable types have been introduced on the Great Western & London and North-Western Railways, both classes being of the 4-4-2 type and constituting adaptations of the standard express locomotives of the respective railways. The coupled wheel diameters are, respectively, 80 inches and 75 inches, and the engines are intended for fast main-line service where the runs are not too long between stops. One of these engines for the latter of these railways is shown in Fig. 4.

A somewhat remarkable corollary to the extensive use of rail-motor cars on British railways is the introduction by Mr. Dugald Drummond for use on the London & South-Western Railway of the small, specially designed tank engines represented in Fig. 5. These are used with one or two bogie vestibuled cars of the type usual with rail-motor cars, and are intended to run permanently without being uncoupled from the cars. When running backward the driver controls the combination from the end compartment of the rear coach. The employment of a separable locomotive is finding extensive favour in Great Britain, though most railways are utilizing old tank engines in this way, and the London & South Western Railway is the only one which has, so far, introduced specially designed locomotives for this service.

In France the de Glehn compound system is still almost universal for locomotives for all kinds of work, except on the Paris-Lyons-Mediter-

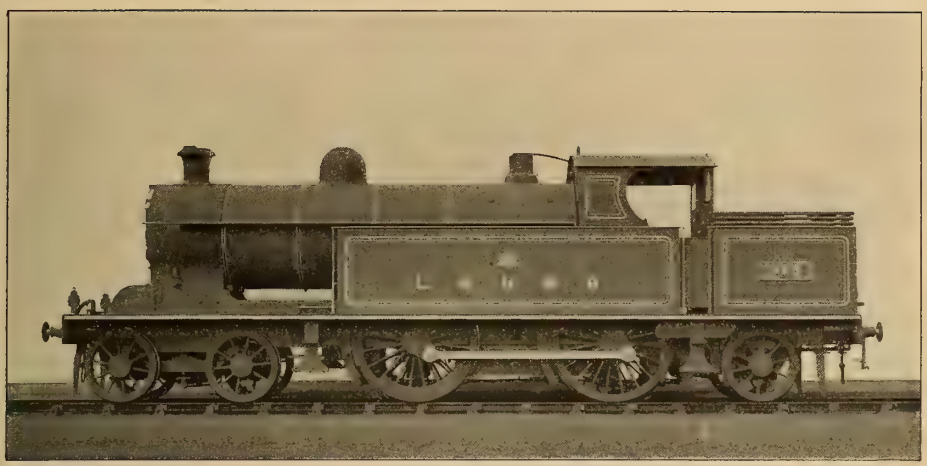


FIG. 4.—PASSENGER TANK LOCOMOTIVE 4-4-2 TYPE LONDON AND NORTH WESTERN RAILWAY

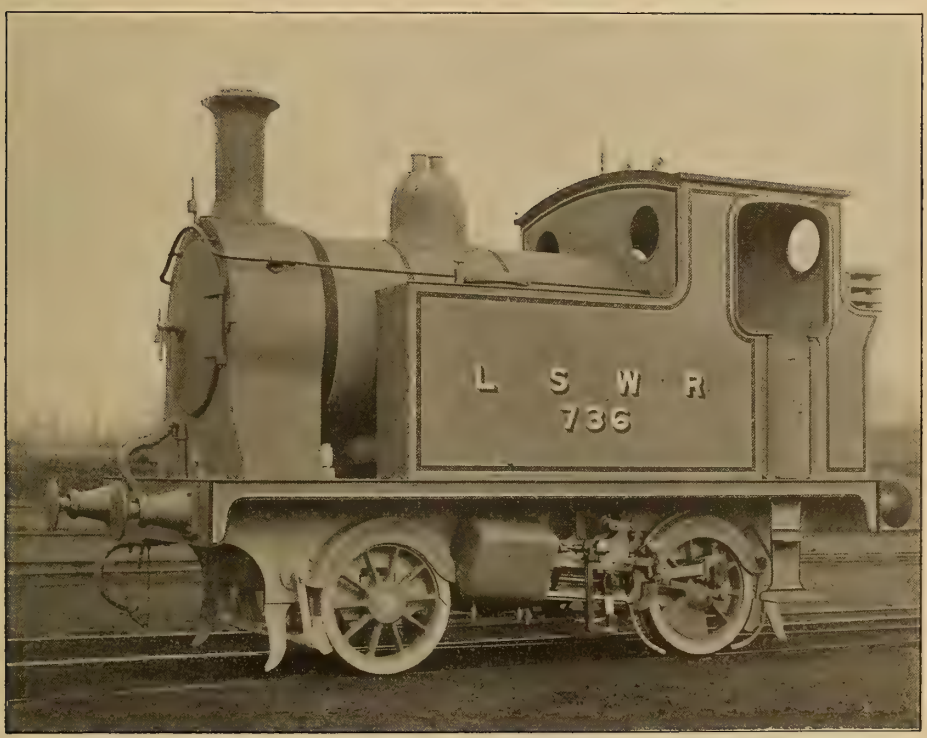


FIG. 5.—SPECIAL TANK ENGINE FOR LOCAL PASSENGER SERVICE. LONDON AND SOUTH WESTERN RAILWAY

FIG. 6.—NEW 4–6–4 COMPOUND TANK ENGINE, DE GLEHN SYSTEM. EASTERN RAILWAY OF FRANCE

ranean Railway, where, however, practice is somewhat similar, but employing the Henri-Baudry compound system. During 1906 no new express locomotive designs were introduced, but on three railways, the Paris-Orleans, Midi & Alsace-Lorraine, new engines will shortly be placed in service of the "Pacific" (4-6-2) type. These are to be large six-coupled compound express locomotives, and they will be the first tender engines of this type in Europe.

Fig. 6 illustrates a remarkable tank-engine design introduced on the Eastern Railway of France. These engines also are de Glehn compounds. They represent a remarkable development in tank-engine design. A similar class has also been placed in service on the Alsace-Lorraine railways, where the locomotive practice requires to be classed with that of France.

Fig. 7 illustrates a large 2-10-0 goods engine, also employed on the Alsace-Lorraine railways for heavy traffic. This design, again, embodies the de Glehn system of compounding.

In Germany the previously existing locomotive designs have been continued, and few actual novelties have to be chronicled, but two or three items require special mention.

Fig. 8 illustrates a huge 4-4-4 express engine recently placed in service on the Bavarian State railways. These are developments of the re-

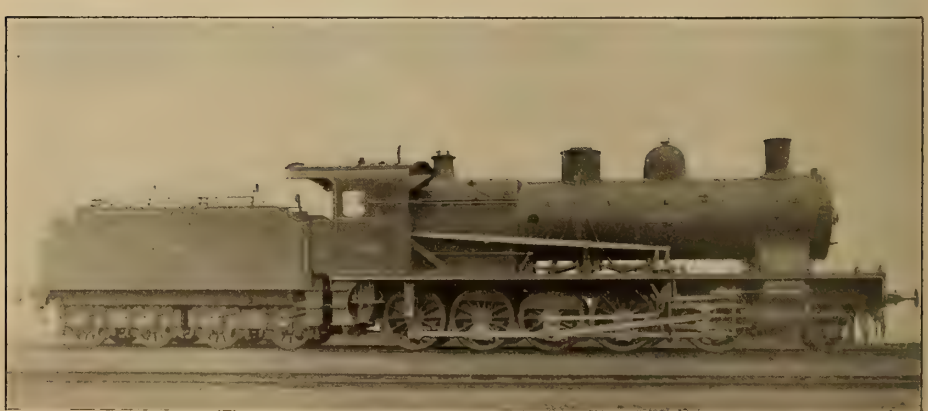


FIG. 7.—DE GLEHN COMPOUND ENGINE FOR HEAVY GOODS TRAFFIC. ALSACE-LORRAINE RAILWAYS

markable 4-4-2 and 4-6-6 engines introduced a few years ago and which have been supplied by the firm of J. A. Maffei, of Munich, for service on the Bavarian & Baden State, and the Palatinate railways. Like their predecessors, these engines are four-cylinder compounds according to their Maffei system, and they comprise several American features of construction. They are fitted with very large, wide fire-boxes, and this is the principal reason for the use of

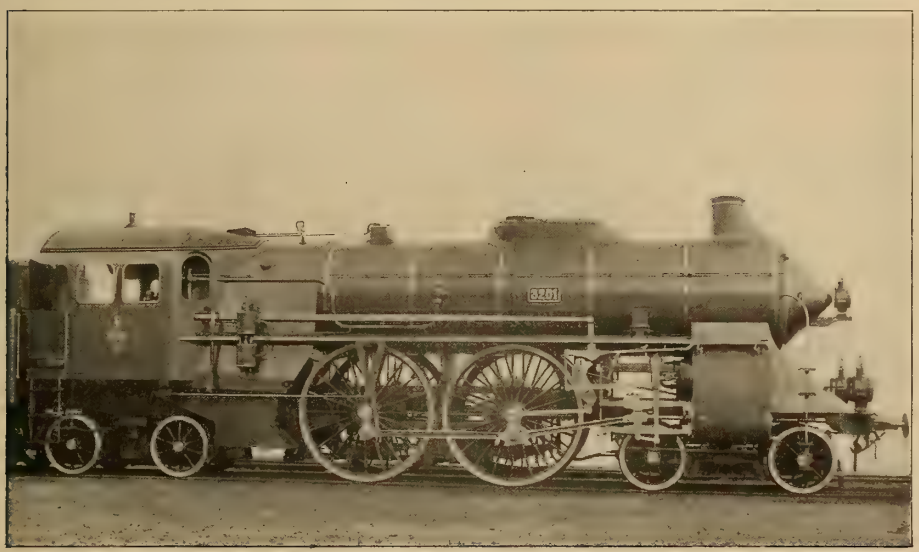


FIG. 8.—FOUR-CYLINDER COMPOUND EXPRESS LOCOMOTIVE FOR THE BAVARIAN STATE RAILWAYS. J. A. MAFFEI, MUNICH

a bogie at the trailing end of the engine.

They are also equipped with the Pielock superheating apparatus, so that a good test is available of the efficiency of superheating when combined with compounding.

In connection with the Milan Exhibition of 1906, several interesting German locomotives were shown, and two of these will now be described.

Probably the most interesting of these, from an engineering point of view, were those exhibited by the Hanover Machine Works and fitted with the Lentz valve gear and poppet valves. Fig. 9 illustartes a six-coupled tank locomotive, fitted with both arrangements. The poppet valves have also been fitted to a class of 4-4-2 four-cylinder compound locomotives for the Prussian State railways, with apparently very satisfactory results.

Fig. 10 illustrates the usual construction and operating gear of the poppet valve mechanism. Four spring-loaded poppet valves are employed for each cylinder, two for admission, and two for exhaust, and these are operated in order by a bar reciprocated by the valve gear, and having cam projections bearing against rollers carried by the valves and so arranged that the action of these cam projections causes the valves to be operated at the correct times and maintained open as long as required, the springs causing their closure when permitted. In the case of the locomotive illustrated, the valve-operating bar is reciprocated by a rocking arm that is driven by the Lentz valve motion. In other cases the operating bar is reciprocated directly from ordinary valve gear. Although there is a fixed re-

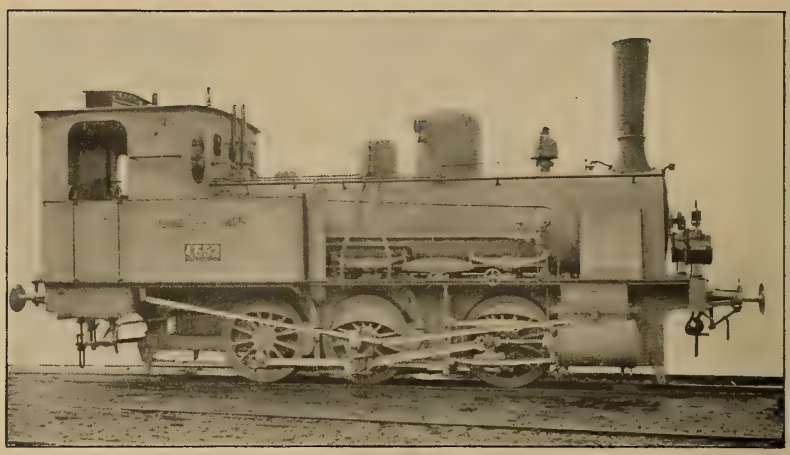


FIG. 9.—LOCOMOTIVE FITTED WITH POPPET VALVES AND LENTZ VALVE GEAR, ALSO WITH PIELOCK SUPERHEATER. HANNOVER MACHINE WORKS, LINDEN NEAR HANNOVER

lation between inlet and exhaust valves as regards opening and closing, their operation as a whole can be adjusted through the valve gear in practically the same manner as with ordinary valve gears.

The Lentz valve motion comprises a small eccentric, mounted on the pin of a return crank, the eccentric being connected by the valve rod shown to the valve operating rocking shaft. For adjusting purposes the rod extending from the cab, and which is controlled by the usual reversing shaft or mechanism, engages by a spiral thread so as to cause proportionate rotation of the spindle which carries the eccentric. This spindle again engages with the eccentric by a spiral threaded arrangement so as to cause adjustment of the eccentric upon its spindle, thereby varying the operation of the poppet valves as required.

Fig. 11 illustrates a large, steep gradient tank engine for the Prussian State railways, built by the Berlin Machine Works, and also exhibited at Milan. This engine is a non-compound, but is fitted with the Schmidt superheating apparatus. The main features of the design are well shown in the photograph.

Rail motor-cars are used in several districts of Germany, as well as other continental countries, but small

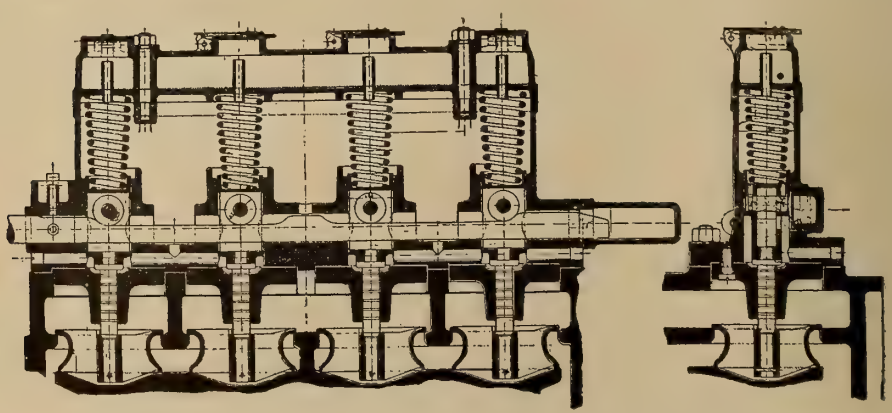


FIG. 10.—POPPET VALVE ARRANGEMENT FOR HANNOVER LOCOMOTIVE ILLUSTRATED ABOVE

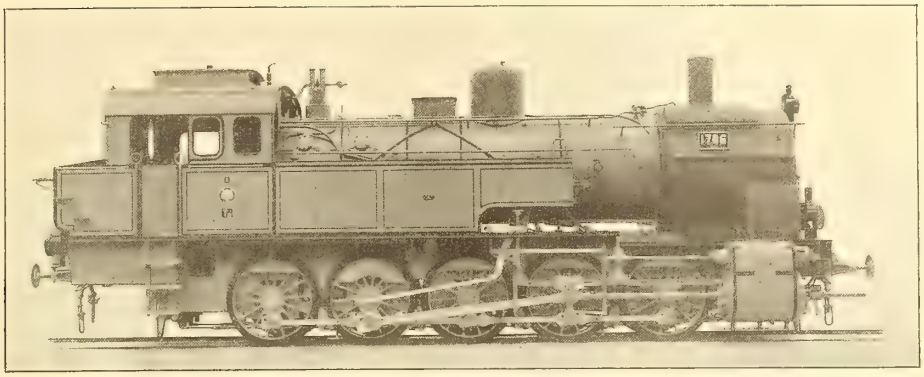


FIG. 11.—TEN-COUPLED TANK ENGINE FOR THE PRUSSIAN STATE RAILWAYS, FITTED WITH SCHMIDT SUPERHEATER. BERLIN MACHINE WORKS, BERLIN

locomotives designed for hauling "light" trams are used in some cases by preference, and Fig. 12 illustrates an engine for this service, built by the firm of Krauss & Co., of Munich. These engines are somewhat remarkable in design, and some of them, including that illustrated, are fitted with the Schmidt superheater.

A somewhat similar design employed on the Bavarian State railways has four coupled wheels, but these are operated through the coupling rods from an intermediate crank, mounted on the actual driving shaft, which is not provided with wheels.

In Austria, Belgium, Denmark, Scandinavia, Russia, Spain and Portugal, Holland, and other parts of Europe, the writer is not aware of any specially remarkable locomotives introduced in 1906, except that a class of 4-4-2 compound express locomotive is now being constructed by the Hanover Machine Works for the Danish State Railways, and in Austria a new class of 2-10-0 mountain locomotive has been placed in serv-

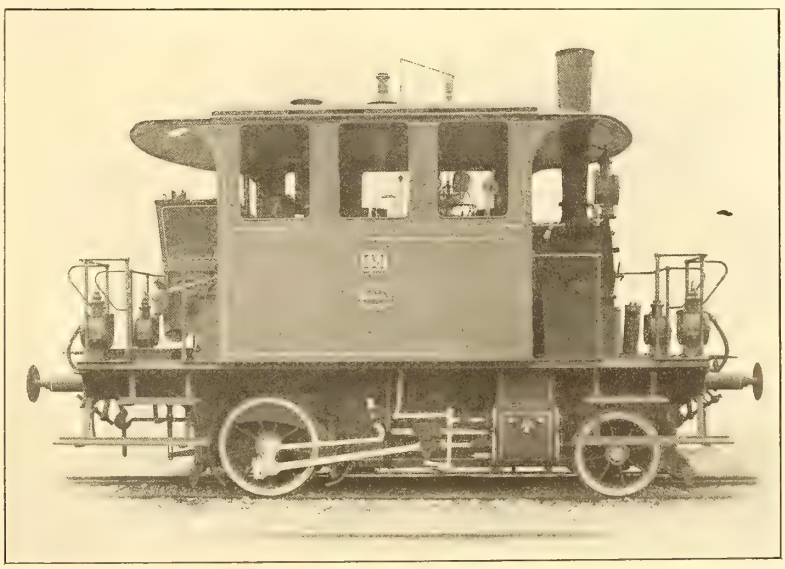


FIG. 12.—RAIL MOTOR CAR, WITH SCHMIDT SUPERHEATER. KRAUSS LOCOMOTIVE WORKS, MUNICH

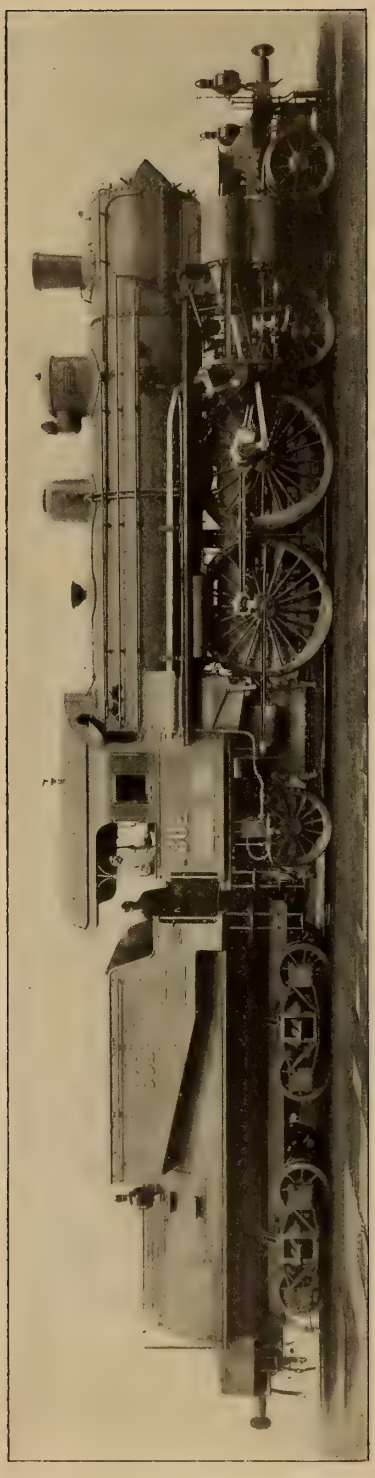


FIG. 13.—FOUR-CYLINDER COMPOUND EXPRESS LOCOMOTIVE FOR THE HUNGARIAN STATE RAILWAYS

ice, but in Hungary and Italy, some interesting locomotives have been introduced.

Fig. 13 illustrates a large four-cylinder compound 4-4-2 locomotive now employed on the Hungarian State Railways, these being the first four-cylinder compound engines (other than tandem and articulated) in that country. This engine was exhibited at the Milan Exhibition. The design is a notable one and compares favourably with the most up-to-date practice in other parts of Europe. Two sets of valve gear only are employed, and the steam distribution is controlled by piston valves. The fire-box is of the "wide" type. The tender is constructed in accordance with the well-known "Vanderbilt" design, used on several American railways.

On the same railways an interesting class of articulated locomotive has been introduced and one of the engines is shown in Fig. 14. The main features correspond with usual practice in reference to the Mallet compound articulated type, but several interesting features are embodied, notably the use of large piston valves, an unusual practice with engines of this type.

In Italy the locomotive event of the year is the supply of American built and designed engines to the State Railway Administration. One class is a series of 4-6-0 express locomotive built by the Baldwin Works of Philadelphia, and compounded according to the Vauclain four-cylinder balanced system. These are, it is thought, the first engines compounded according to this system, to be supplied for service outside the United States. The other class, one of which is shown in Fig. 15, consists of a series of non-compound "consolidation" (2-8-0) locomotives for freight and mountain service. Both classes correspond with American practice, varying therefrom only as regards detail fittings, cabs, etc., which are in accordance with Italian standards.

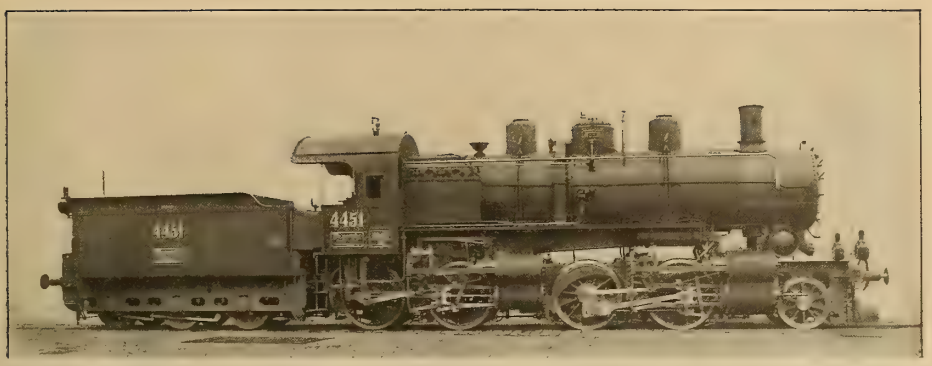


FIG. 14.—NEW ARTICULATED LOCOMOTIVE. HUNGARIAN STATE RAILWAYS

Two interesting locomotives for still larger 0-8-8-0 articulated loco- service in South America will now be considered.

Fig. 16 shows a large 2-10-0 goods locomotive built by the firm of Robert Stephenson & Co., Ltd., of Darlington, England, for the Argentine Great Western Railway. The wide gauge (5 feet 6 inches) allows considerable freedom of design, but even when this is considered, the engines are very large and powerful, the boiler, which is provided with a huge Belpaire fire-box, being of great size.

The locomotive illustrated in Fig. 17 is also for use in Argentina, but is employed by the Argentine Central Northern Railway, which is of 3-foot 6-inch gauge. Owing to the comparatively light construction of track, and the numerous curves, the Mallet articulated type is employed for passenger and goods traffic. In the former case the engine has four coupled wheels and a pair of leading wheels in the forward pivoted truck, while the rear set of wheels is six coupled. Consequently the wheel arrangement is that known as 2-4-6-0. The goods engines, which have slightly smaller boilers, have two sets of six-coupled (smaller) wheels. One of these latter engines is shown in Fig. 17. These engines have been designed and built by the well-known firm of A. Borsig, of Tegel-bei-Berlin.

Dealing now with American locomotive practice, Fig. 18 illustrates in line diagram a large "Prairie" (2-

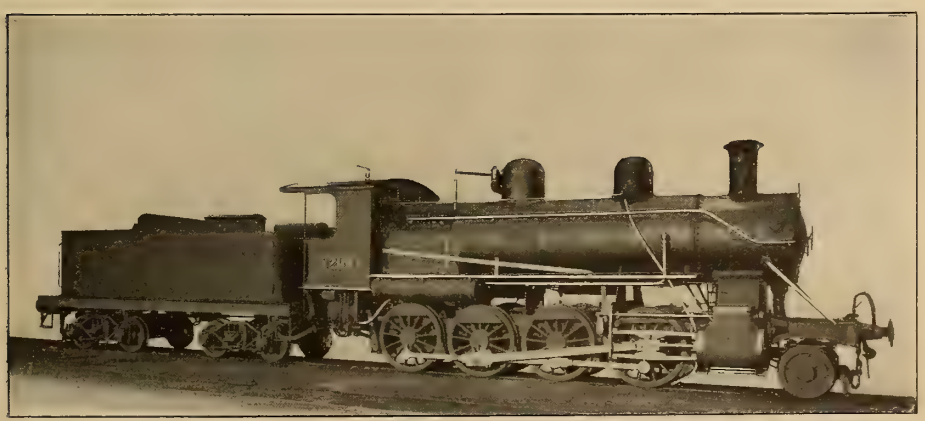


FIG 15.—CONSOLIDATION LOCOMOTIVE FOR ITALIAN STATE RAILWAYS. BALDWIN LOCOMOTIVE WORKS, PHILADELPHIA

FIG. 17.—ARTICULATED LOCOMOTIVE FOR THE ARGENTINE CENTRAL NORTHERN RAILWAY. BORSIG LOCOMOTIVE WORKS, BERLIN

6-2) type locomotive built by the American Locomotive Company for the Pennsylvania Railroad. These engines, which are non-compound, are fitted with the Walschaert valve gear. This gear is now being employed somewhat extensively in American practice. The trailing wheels are fitted in Cole radial trucks.

Fig. 19 illustrates a large 4-6-2 (Pacific type) locomotive built by the same firm for the Northern Pacific Railroad. This also is non-compound, and the Cole radial truck is employed, but the ordinary valve motion is fitted.

Fig. 20 illustrates a somewhat similar locomotive supplied by the Baldwin Works for the Southern Railroad.

The "Mastodon" (4-8-0) type was in considerable favour some years ago in the United States, but has fallen into comparative disuse of late. Fig. 21, however, illustrates a recent example of the type supplied by the Baldwin Works for the Norfolk & Western Railroad.

Of recent types the only novelty with eight-coupled wheels that has been introduced is the "Mikado" (2-8-2) type, and an engine of this type, built by the Baldwin Works for the Lake Champlain & Moriah Railroad is shown in Fig. 22. In this case the Walschaert valve gear is employed.

The locomotive shown in Fig 23 is one of the most remarkable of the year. It is designed for the very heaviest switching service and has ten coupled wheels, there being no

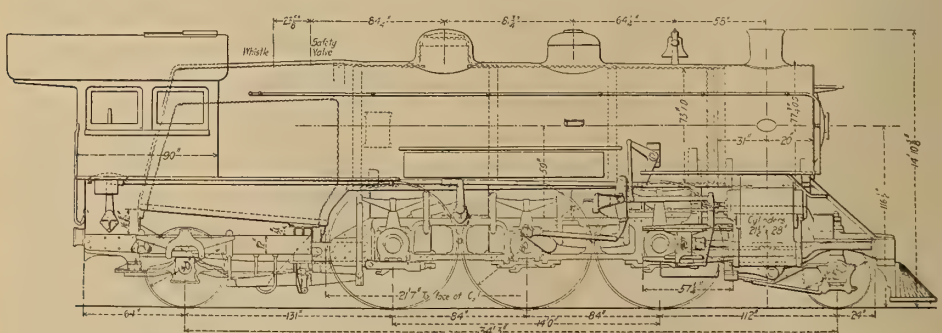


FIG. 18.—PRAIRIE TYPE ENGINE WITH WALSCHAERT VALVE GEAR. AMERICAN LOCOMOTIVE COMPANY, SCHENECTADY, N.Y.

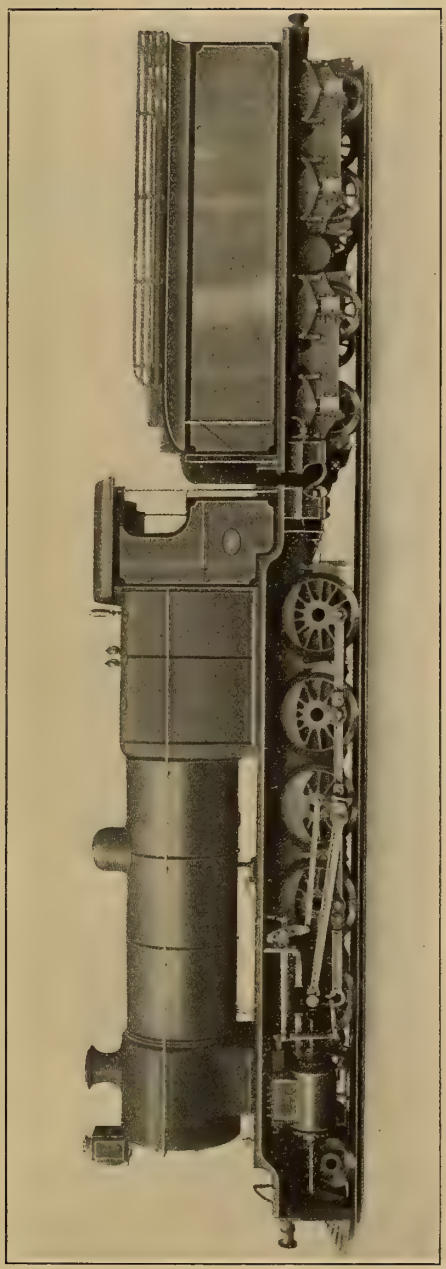


FIG. 16.—GOODS LOCOMOTIVE FOR THE ARGENTINE GREAT WESTERN RAILWAY. ROBERT STEPHENSON & CO., LTD. DARLINGTON, ENGLAND

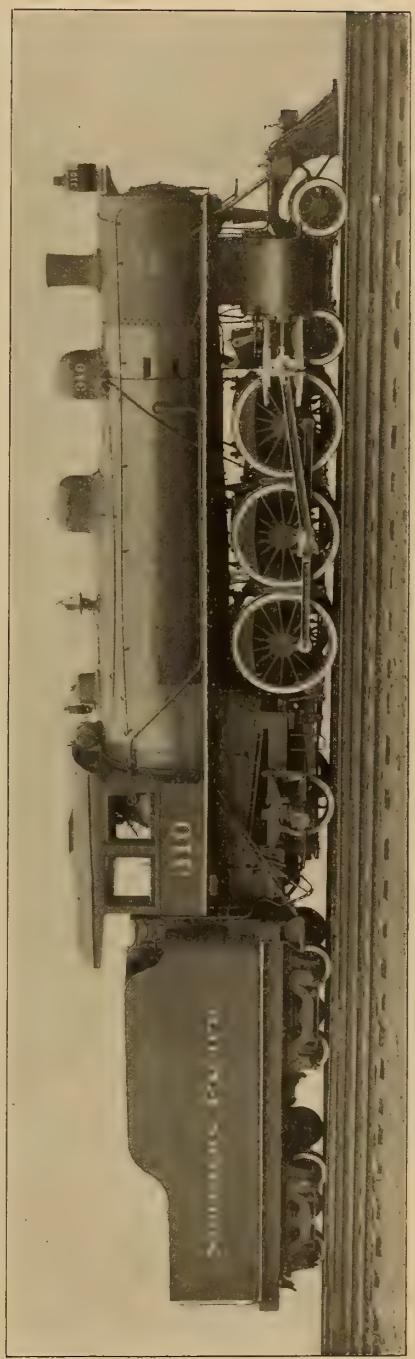


FIG 19.—PACIFIC TYPE ENGINE NORTHERN PACIFIC RAILROAD. AMERICAN LOCOMOTIVE COMPANY SCHENECTADY, N. Y.

FIG. 21.—LARGE 4–8–0 FREIGHT LOCOMOTIVE, BUILT FOR THE NORFOLK & WESTERN RAILROAD BY THE BALDWIN LOCOMOTIVE WORKS

other wheels, in accordance with switching practice.

It was supplied by the American Locomotive Company to the Lake Shore & Michigan Southern Railway. The dimensions, particularly of the boiler, are specially remarkable, in view of the service for which the engine is designed, although it must be remembered that in some yards the work required of the switching locomotives is considerably more severe than that of the road locomotives, for at times they may be required to move the load of two ordinary freight trains at one operation, and at all times rapid acceleration with long loads is a time-saving consideration.

In addition to the foregoing, many interesting American locomotives could also be described, did space permit. A somewhat peculiar feature is the comparatively small proportion of compound locomotive introduced in 1906 for United States railways, and our selection does not include a single one. The recent 2-6-6-2 Mallet compound freight locomotive recently placed in service

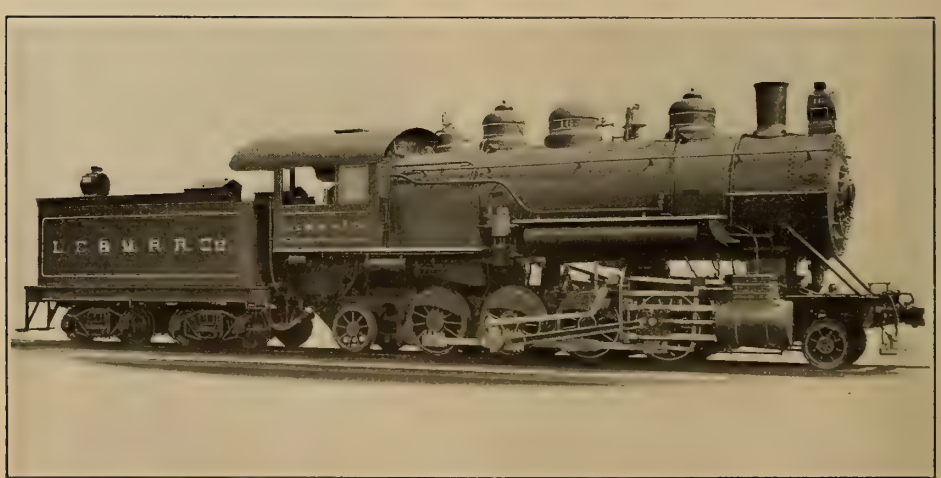


FIG. 22.—MIKADO TYPE FREIGHT LOCOMOTIVE, BUILT AT THE BALDWIN WORKS FOR THE LAKE CHAMPLAIN & MORIAH RAILROAD

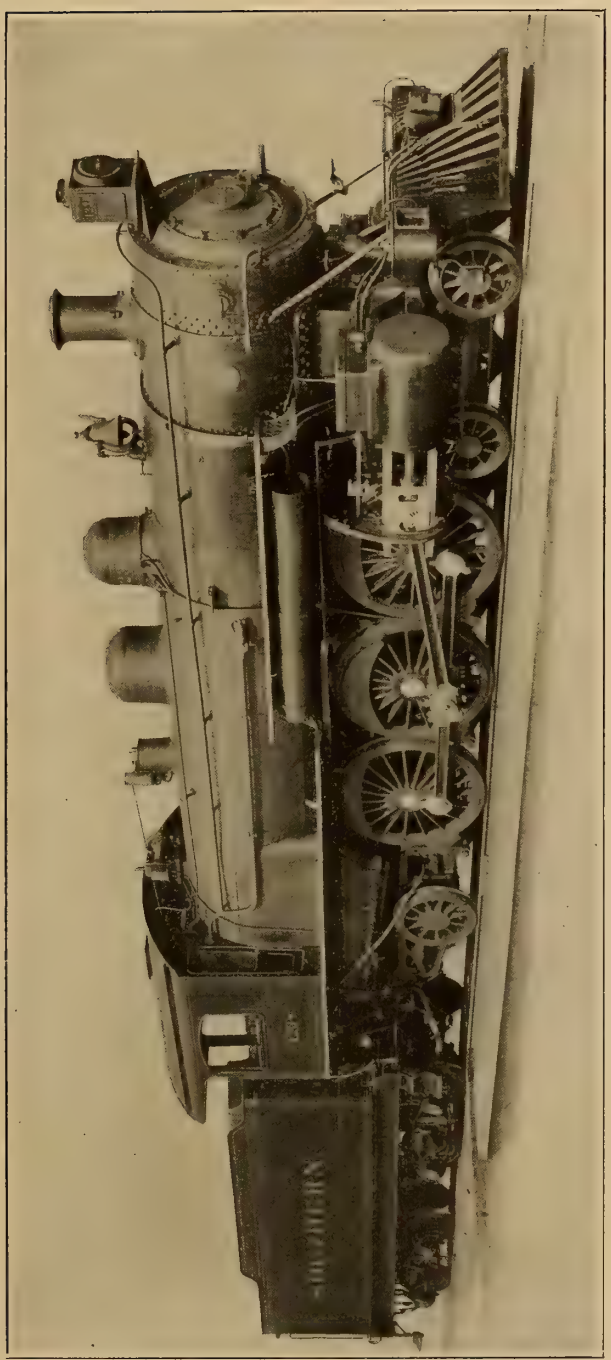


FIG. 20.—NEW 4–6–2 EXPRESS LOCOMOTIVE, BUILT BY THE BALDWIN LOCOMOTIVE WORKS FOR THE SOUTHERN RAILWAY, U. S. A.

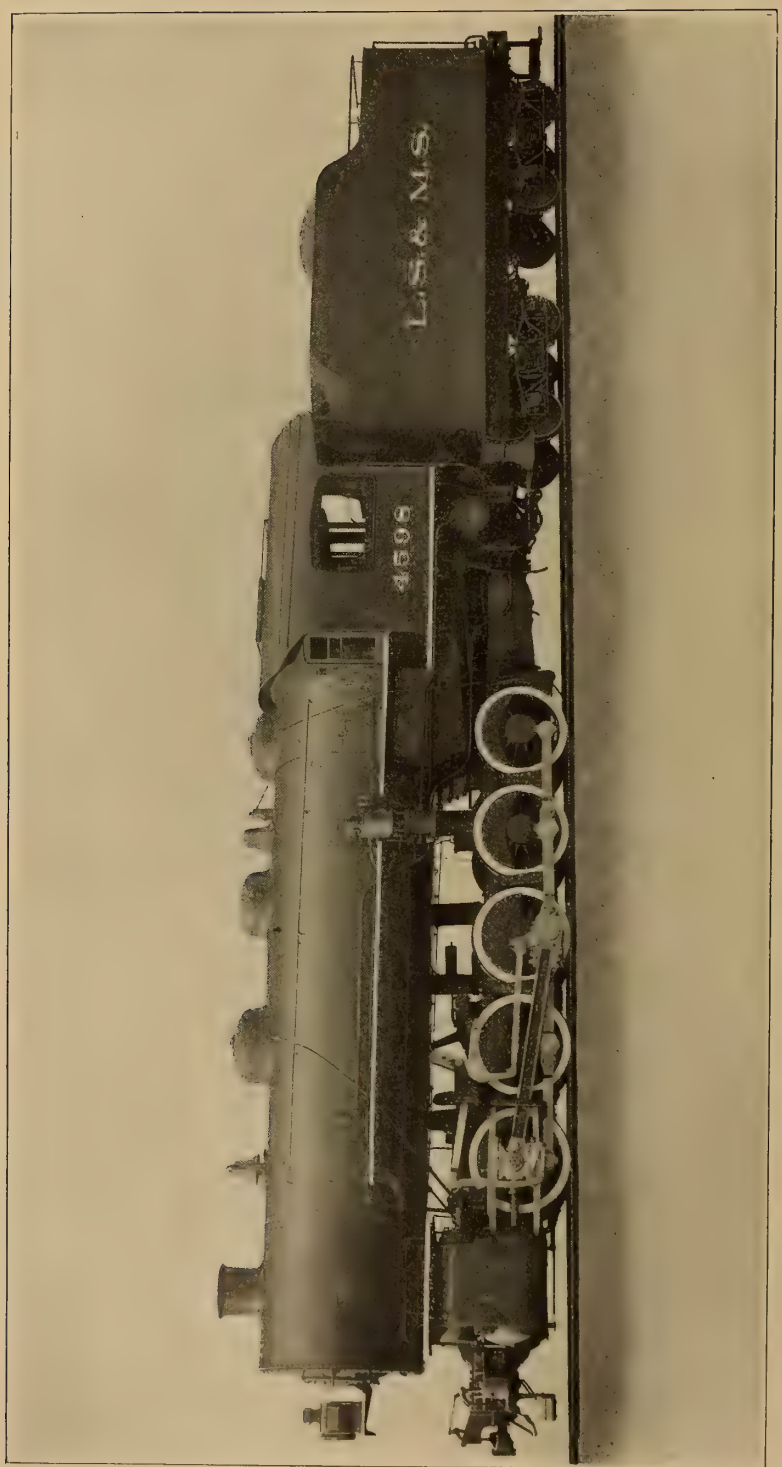


FIG. 23.—TEN-WHEEL HEAVY SWITCHING LOCOMOTIVE, BUILT FOR THE LAKE SHORE & MICHIGAN SOUTHERN RAILWAY BY THE AMERICAN LOCOMOTIVE COMPANY SCHENECTADY

by the Baldwin Works on the Great Northern Railroad, has already been described in these pages by Mr. Fry. Reference is also necessary to the still larger 0-8-8-0 articulated locomotives now being constructed by the American Locomotive Company for the Erie Railroad.

The writer has now considered briefly and comprehensive, though not exhaustive, a survey of the most remarkable locomotives of 1906, and it will be seen that the year has well maintained the standard of progress set by preceding years, while there seems to be no prospect, even yet, of finality being reached.

In conclusion the writer must acknowledge his indebtedness to the various locomotive building firms who have courteously provided the photographs and drawings reproduced herewith, and, in one or two cases, acknowledgment is necessary to railway officials.

A table is appended giving the leading dimensions of the locomotives illustrated in this article, as well as those of some of the engines mentioned incidentally.

PARTICULARS OF LOCOMOTIVES ILLUSTRATED AND SOME OF THOSE DESCRIBED

Country.	Railway.	Type.	H. P. Cylinders.	L. P. Cylinders.	Diameter of Coupled Wheels.	Steam Pressure.	Heating Surface, Square Feet.	Grate Area.	Weight (tons)	
									On Coupled Wheels.	Total.
Great Britain	N. E. R.	4-4-2	14½ x 26	22 x 26	7′ 1″	225	1962	29.	39¼	73¼
Great Britain	N. B. R.	4-4-2	20 x 28	.....	6′ 9″	200	2256	28.5	40	74½
Great Britain	G. W. R. (4 H. P. Cylinders)	4-4-2	14⅜ x 26	.....	6′ 8½″	225	2142	27.	39½	74½
Great Britain	C. R.	4-6-0	19 x 26	.....	5′ 9″	180	2178	21.	49	64
Great Britain	G. S. W. R. (1)	4-6-0	19½ x 26	.. ..	5′ 1½″	160	1599	24.8	44	57
Great Britain	G. W. R. (Tank)	4-4-2	18 x 30	.....	6′ 8½″	195	1518	20.3	37	75
Great Britain	L. N. W. R. (Tank)	4-4-2	19 x 26	.....	6′ 3″	175	1939	22 4	39½	74¾
Great Britain	L. S. W. R. Rail.. ..... Motor Locomotive	2-2-0	10 x 14	.....	3′ 0″	150	571	9.5	.....	.....
France	C. de Fer de l'Est (Tank)	4-6-4	14 x 25½	22 x 25½	5′ 3½″	225	1582	26.	.....	88¾
Alsace	Alsace-Lorraine	2-10-0	15⅜ x 25⅝	23⅝ x 25⅝	4′ 4¾″	213	2696	29.8	.....	73½
Germany	Bavarian State	4-4-4	16 x 25½	24 x 25½	7′ 2½″	205	2722	50.5	32	82
Germany	Prussian State (Tank)..... Rail..... Motor..... Locomotive	0-10-0 2-2-0	24¼ x 25½	.....	4′ 6″	170	1752	24.25	71½	71½
Austria	State Railways	2-10-0	14½ x 28¼	24¾ x 28¼	4′ 9″	235	2777	49.	67½	77
Hungary	State Railways	4-4-2	14 x 26	24¼ x 26	6′ 10½″	227	2823	41.9	31½	73½
Hungary	State Railways	2-4-4-2	15 x 26	25¼ x 26	4′ 7″	227	2500	35.7	63	74
Italy	State Railways	4-6-0	15½ x 24	25 x 26	6′ 0½″	200	2168	33.25	44½	64½
Italy	State Railways	2-8-0	20 x 26	.....	4′ 7″	200	2084	37.5	58	65
Argentine	Great Western	2-10-0	19½ x 28	.....	4′ 3″	180	2440	36.	73	79½
Argentine	Central Northern	2-4-6-0	13 x 21½	20½ x 21½	4′ 3½″	170	1820	35.	.....	47¼
Argentine	Central Northern, 3′ 6″ Gauge	0-6-6-0	13 x 21½	20½ x 21¼	3′ 7¼″	170	1612	32.	46	46
United States	Pennsylvania	2-6-2	21½ x 28	.....	6′ 8″	200	3881	55.	74½	104
United States	Northern Pacific	4-6-2	22 x 26	.....	6′ 3″	200	3528	43.5	63	97
United States	Southern	4-6-2	22 x 28	.....	6′ 0½″	220	3895	54.25	63	97¼
United States	Norfolk & Western	4-8-0	21 x 30	.....	4′ 8″	200	2940	44.5	62	87
United States	L. Champlain & Moriah	2-8-2	22 x 28	.....	4′ 2″	200	3300	57.	75½	96
United States	L. S. & M. S. R.R.	0-10-0	24 x 28	.....	4′ 4″	200	4625	55.	120½	120½
United States	Great Northern	2-6-6-2	21½ x 32	33 x 32	7″	200	5658	78.	141	158⅛
United States	Erie	0-8-8-0	25 x 28	39 x 28	4′ 3″	215	6108	100.	183	183

THE ROCK DRILL AND ITS SHARE IN THE DEVELOPMENT OF NEW YORK CITY

By Frank Richards

NEW YORK seems destined to become one of the most populous cities in the world. It is unique in situation, in configuration, and in opportunity.

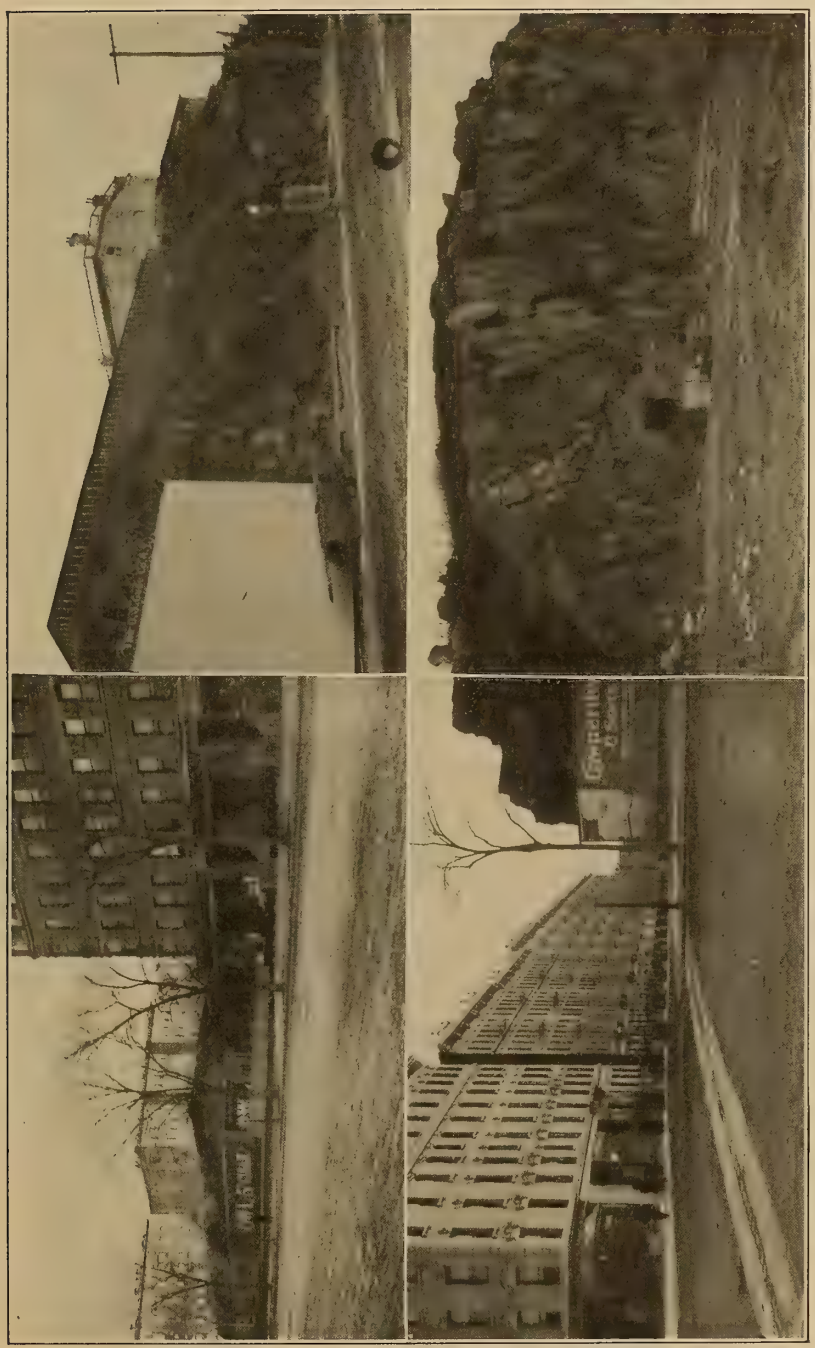
Originally occupying a triangle, of which the Hudson River and the extended forefinger of Long Island Sound defined the apex, the city has covered the long parallelogram of Manhattan, which extends northward from the base of the triangle, has spread across the circumscribing waters on every side and is still reaching out with a grasp more eager than ever.

The rapid increase of population and the wide extension of the area occupied have entailed upon the present upbuilders of New York and upon those who are constantly planning its future, many problems which each seem to be peculiar, in that none of them admit of final and permanent solution, but each can only be progressively and continuously unrolled, with still a tangled skein at the end. There are many sanguine ones who think they can see a decade ahead, but no prophetic vision can reach the end of the century, and none can tell what then will be our needs or our ways and means for satisfying them.

Larger and better schools are being built faster than ever, but the scholars to crowd each building are always there before the building is completed. Two successive systems of water supply have been constructed, each the engineering triumph and marvel of its day, but already wider watersheds are sought and more capacious reservoirs and further reaching aqueducts planned.

The transportation problem of New York has realized this process of gradual revelation and development perhaps more strikingly than any other. For the purposes of business the original triangle of the city has always retained its pristine monopoly, the solid and exclusive business area still extending not more than one-quarter of the length of the parallelogram above it. Here, in the busy hours, the breadwinners are congregated, and every night and morning they have to be carried, most of them far, to and from their homes.

In any large office building in the downtown district, there will be those who live severally in Brooklyn, on Staten Island, in Jersey City, Newark, Paterson, the Oranges and a score of other towns in the neighbor State across the Hudson. Many will live in Harlem, and some on the East Side; others will come from the borough of the Bronx, from Yonkers and the towns to the north or along the Sound, even into Connecticut. Wherever they live, they all, practically, require transportation night and morning. Besides this regular host of travelers, provision must always be made for the continuous incidental local movements which business necessitates, for the trips for shopping and sight-seeing and visiting, and for the amusement crowd of the later hours. With necessarily great fluctuations as to volume, there is a never-



FIGS. 1-4.—BLOCKS OF ROCKS EXISTING IN NEW YORK AT THE PRESENT TIME, AND RISING 20 TO 60 FEET ABOVE STREET LEVEL

FIG. 5.—CUTTING BUILDING LOTS OUT OF SOLID ROCK

ceasing ebb and flow of travel night and day.

Half a century ago the only public conveyance in New York was the omnibus. The writer hereof first saw the city in 1861, and Broadway, down town, was then so crowded, mostly with omnibuses, that it was much more difficult and dangerous for a pedestrian to cross than it has ever been in recent years. The longest route of the Broadway omnibuses then extended up Fifth avenue to the country at Forty-second street.

At the date spoken of, the first horse-car line was already in operation and horse cars were soon after running all over the city, finally getting possession of Broadway. Later, there was the costly installation of the cable in place of the horse on four of the principal longitudinal lines of the city, and the cable was only fairly and fully established before it in turn was superseded, again at great cost, by the underground electric trolley. In all the successive changes each successor has seemed to be, and indeed actually has been, the best available at the time.

FIG. 6.—ROCK DUMPED FOR FILLING

FIGS. 7-10.—TRANSFORMATION OF WASHINGTON HEIGHTS FROM COUNTRY RESIDENCES TO ROWS OF FLATS

FIG. 11.—CUTTING FOR SEWER

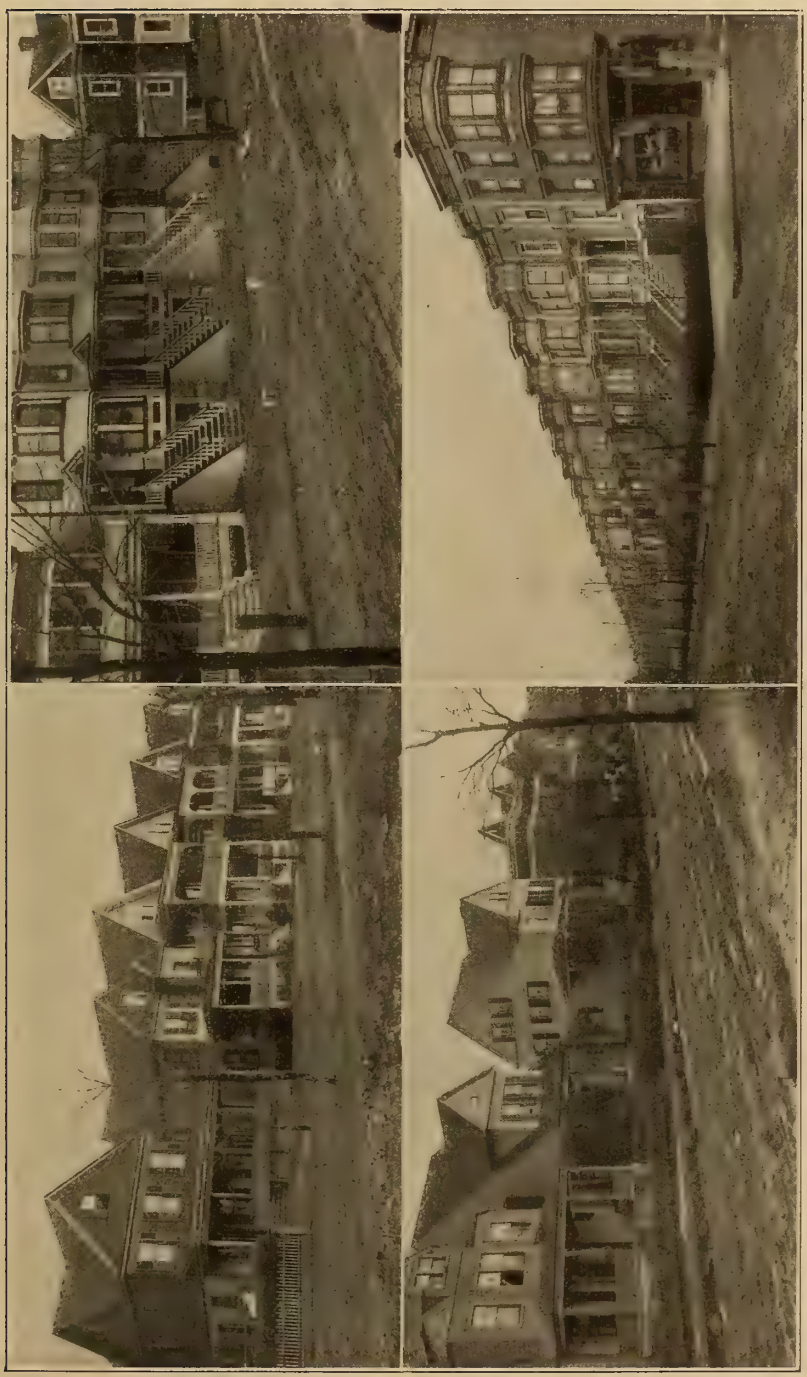
Each has been at the time an improvement upon its predecessor, but neither has satisfied the then present or the immediately prospective public need.

The elevated railroads of the city have carried it through the same development of experience. They have had their turn and have really done valuable service for a quarter of a century. They, too, have reached their practical limit. While they have been successively extended, improved in many details of operation and worked in the "rush hours" to their permissible capacity, entailing much inconvenience and discomfort, they, too, have been unable to keep up with the growth of population and the requirements of still rapidly increasing travel. The building of additional elevated roads obstructing and darkening more of the streets and avenues, is not to be thought of, and suggestions looking in that direction could promise, at best, only temporary relief.

Every time in the development of the city when the conditions have become sufficiently desperate there has been a new departure, involving radical change of system and method and giving promise of largely increased facility and capacity. The very end of the last century saw the citizens of New York in urgent need of, and desperately clamorous for, increased and improved means of transportation. Almost precisely with the beginning of the present century there was also the beginning of a new scheme of local travel, with great promise of ultimate and permanent relief for the entire Greater New York.

The commencement of work on the first subway was, we may well believe, one of the most momentous and

FIG. 12.—A NEW YORK TENEMENT HOUSE



FIGS. 13-16.—TYPES OF DWELLINGS DEVELOPED BY THE EXTENSION OF RAPID-TRANSIT FACILITIES IN NEW YORK

most memorable incidents of the city's growth, and its completion made assurance doubly sure that here was inaugurated a system eminently satisfactory, and, the feature most necessary of all, capable of practically unlimited extension without interfering with other already established interests. The demand now is not for something better than the subway, except as to details, for nothing better is in sight, but for much more of the same, and this demand there will be now continuous working to satisfy. The subway here contemplated is, of course, not only subterranean, but also subaqueous, and is to be extended under the rivers surrounding Manhattan, as well as under the land in any direction, to any distance, and in sufficiently numerous and capacious lines to satisfy the ever-growing needs of the people.

The final adoption of the subway as the way out of our troubles in the matter of rapid and convenient transit is not any more the result of our desperate needs than it is of the modern development of the means, especially of construction and also of operation, and the cheap, reliable and rapid production of the materials required for the work. It is only within very recent years that the subway could have been a possibility, and no engineer would have had the daring to have planned or proposed it in advance of the developments which unlocked the opportunity. The subway, after the excavation, is a creation of modern structural steel and concrete, and for the excavation, it is in like manner the creation of the rock drill and the air compressor. Without these materials and these efficient workers there could, and would have been, no subway.

And here comes to our attention, perhaps the most curious thing of all. Very few people really know how completely the rock drill and the air compressor, both so needful in all the city's subterranean and subaqueous constructive work of the present and the future, are themselves products of the city itself. New York is the home of the rock drill and the air compressor, as well as the field of their most extensive and constant employment to-day. New York also, if not the birthplace of both, was at least the home of the infancy and youth, and it is the one place of all the earth where their abilities and possibilities have been developed and the details of their construction have been adjusted to the work of their lives through constant and strenuous employment and the experiences of actual, practical operations demanding the highest efficiency. Both the rock drill and the air compressor served their apprenticeship in the construction of the later Croton aqueduct. The subway of to-day, or the possibility of it, was developed there and then.

Besides the driving of the 30 miles of tunnel which constitute the aqueduct, the rock drill has had its work to do all over the surface of Manhattan and its contiguous territory. Of all the business activities of the city of New York the first and most continuous is the business of growing. This is the one industry of the city which never stops and which hardly ever has a period of perceptible retardation. The making of new streets and avenues and the extending of the old ones, followed by the erection of additional buildings upon the lands thus made available, goes on despite the fluctuations of general business or the brightening or shadowing of its prospects, and there is certain employment for many men in these lines of activity, whatever may be the general aspect of affairs and regardless of the vicissitudes of Wall street.

New York is a city which is founded upon a rock. It is one of the simplest of operations to draw a line upon a map and to say "here shall be a street," and it is a comparatively easy task also to indicate the grade of it, but to translate the lines of the draftsman into the actual surfaces which the feet of men shall comfortably tread through the fol-

FIGS. 17-19.—VIEWS OF THE NEW YORK SPEEDWAY

The upper illustration shows the south end of Speedway. The central picture is a view of the road near High Bridge. Lower illustration shows Speedway near Washington Bridge

lowing ages, makes work for a multitude of toilers. The attraction of this industrial opportunity reaches far and strong across the seas and draws to our shores the tough and untired ones still eager to accept the strenuous tasks which most of us have grown to despise. The one instrument most potent in the promotion of this most modern inrush of immigrants, so far as New York city is concerned, is undoubtedly the rock drill, and the affiliation here of the Italian and the rock drill is now as constant and as intimate as that of the traditional darky and the mule.

While the drill runner and his helper and all the gang of handlers of the rocks are now most apt to be Italians, the rock drill itself is sure to be a New Yorker born and bred. Wherever it is found at work it is almost invariably either an Ingersoll-Sergeant drill or else a Rand drill, both New York productions and developments.

When a new street is to be run through in, say, the northern section of Manhattan, in the borough of the Bronx, or in other outlying regions of the Greater city, there is usually a lot of rock cutting to be done over some portion, and often a large portion, of it merely to get to the street level. Then there is more rock cutting required for the sewers, water pipes, gas pipes and electric conduits, the veins and arteries and nerves of the city's living organism.

When a street is graded and completed, with gutters and curbstones and "corporation" sidewalks, which consist of single strips of flagstones, the entire surface of the land contiguous to it is often considerably above the street level. Fig. 1 shows a block of rock on upper Seventh avenue between two built-up blocks, and Fig. 2 shows a corner a little further up the avenue. Fig. 3 is a block on the other side of the avenue, and Fig. 4 still another where the rock is 60 feet above the street level. The rock of the same height as this on the next block to the north has already been cut away and now forms a part of one of the smaller parks of the city. There are many blocks such as these in the various newer parts of the city, 10, 20, 50 feet above the street level and this height must be cut down before the lots, if held for sale, are fairly in the market. Fig. 5 shows lots which are being carved out of the solid rock, this job occurring where one avenue parallels another with a great difference in their respective levels.

When lots which have been leveled to the street are to be "improved" or built upon, then there is another big job for the rock drill in cutting out for the basements and foundations of the new buildings. Stone for foundation walls anywhere in the city costs practically nothing except for breaking and sorting and for conveyance to the place required. Stone for con-

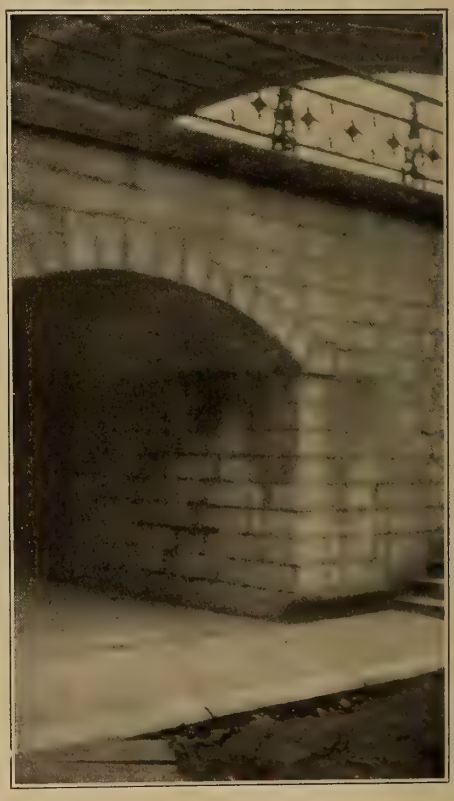
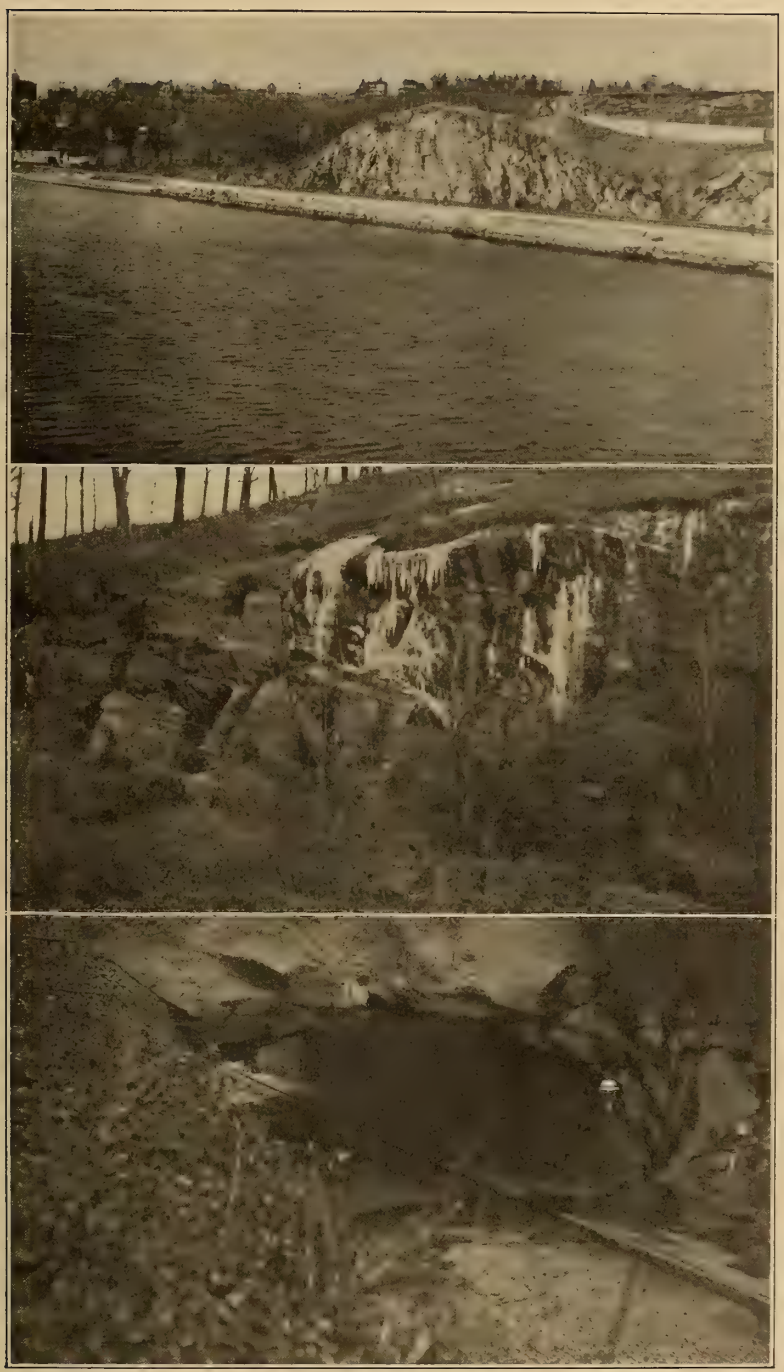


FIG. 20.—SUBWAY FOR PEDESTRIANS UNDER THE NEW YORK SPEEDWAY



FIGS. 21-23.—LARGE ROCKS IN NEW YORK

The upper illustration is at Marble Hill, Harlem Ship Canal, and shows the tracks of the N. Y. Central R. R. The central view is a Rock Cutting on Lafayette Boulevard. The lower picture shows a Rock Bridge on Central Park Cross Road.

FIG. 25.—A PORTION OF THE PALISADES RESTORED BY BLASTING AWAY THE BASE

crete also costs only for the crushing and carting. The larger surplus of broken rock is used for filling in lots which are sufficiently below the normal level to require it, and more of it goes to the making of new land out into the water.

Fig. 6 shows rock used for filling, and the usual practice in such cases is to fill up to the street level, although everyone knows that when the time for building comes much of this filling must be laboriously removed. When a new street is to be opened the sewers and water pipes are planned also, and their locations and levels are determined. It would seem that when the rock cutting for the street grade was going on much expense might be saved if the cutting for the sewers and the water pipes could be done at the same time. This, however, seems frequently not to be done. Each operation of excavation seems to be carried out under a different contract, and the rock drill may thus have from three to six different jobs in a neighborhood instead of one or two to do the same work. The click of the rock drill thus be-

FIG. 24.—TURN OF TROLLEY ROAD CLIMBING THE PALISADES

FIG. 26.—HIGH BRIDGE WITH WASHINGTON BRIDGE BEHIND IT

comes a very familiar sound to the frequenters of the newer portions of the city, and the frequent explosions of dynamite, usually night or morning, suggest a long sustained siege of artillery.

The rock drills for this line of work are all steam actuated, the locations of operation constantly changing, and the work being done mostly by independent contractors who could not well co-operate in the use of a

FIG. 27.—WASHINGTON BRIDGE OVER THE HARLEM RIVER

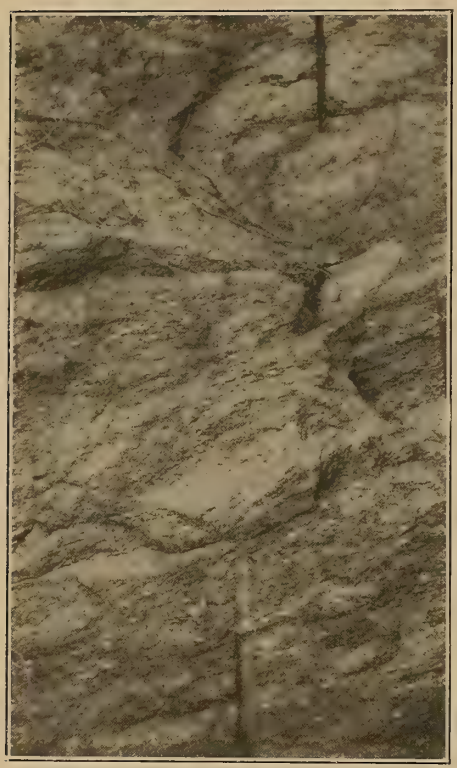


FIG. 28.—HAND-DRILLED HOLES. OLD CROTON AQUEDUCT

compressed-air plant. Occasionally when there is only a little rock to be removed in a building lot it will not even pay to bring the boiler and the drills with their runners, and then we see the hand drills employed.

There is a phase of this work of developing and "improving" the city which is going on, and in which the rock drill is so constantly and so strenuously employed, which it is not entirely pleasant to contemplate. The present results accomplished do not seem to be altogether admirable. Recently developed lines of rapid transit have made new regions of the city accessible. There is to be a rush of immigrants and settlers into these parts, and the immigrants are being provided for. Fig. 7 suggests the character of one of these locations, Washington Heights, before the change comes. Fig. 8 shows the "improvements" as they are being carried on all around this spot, which can itself survive but a little while. Fig. 9 is the last of a neighboring mansion. Fig. 10 shows the "improvements" nearly completed, so far as one street is concerned. Where this row of tenements now stands the rock was at least 50 feet high above the present street level, and upon the top of it was a large mansion of the olden time. Fig. 11 shows incidentally the rock cutting for a small sewer in a street cut through some time before.

Fig. 12 is the front of one tenement of a somewhat cheaper class in a row which occupies the block adjoining that shown in Fig. 10. The width of each of these tenements is 33 feet, and the depth of the building is 90 feet, the lot being 100 feet. There is a slice off one side of each tenement extending to within about 20 feet of the front, thus forming, with a corresponding narrowing of

FIG. 29.—HAND-DRILLED HOLE FIRED WITH BLACK POWDER

FIG. 30.—UP-TO-DATE ROCK DRILLING IN NEW YORK

the next tenement, an open space 10 feet wide for light and air, forty windows opening into this space with twenty-eight in front and ten in the rear of each tenement. From the total sectional area of each story is to be deducted that of the walls and partitions, the halls and stairways, and the net available space then is divided into four apartments for each floor, four houses, four homes, for people not nearly of the lowest or poorest class; rather for the better class of wage earners. All the functions of housekeeping and of family living are assumed to be provided for. On the first floor the apartments each comprise four "rooms" and the lowest rent is $25 per month. On the floors above there are five and six rooms to the apartment and the rent goes to above $30 per month.

Each tenement thus provides living places for twenty families, besides that of the janitor in the basement. Upper New York is being built up almost entirely in this style, simply because it is the best paying scheme which has been devised.

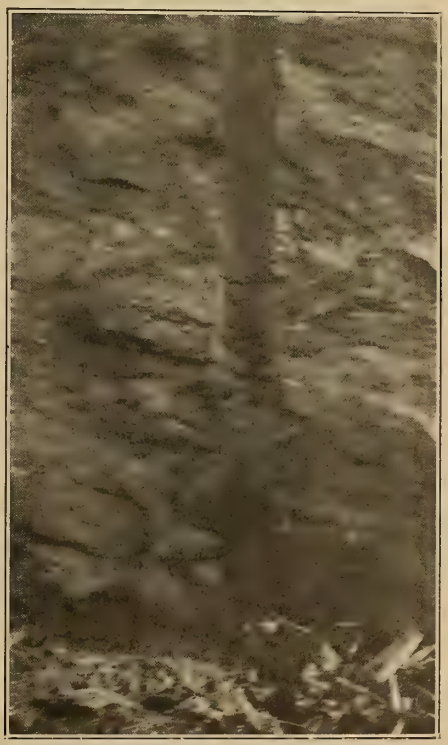


FIG. 31.—EFFCT OF DYNAMITE UPON THE DRILLED HOLE

FIG. 32.—RETAINING WALL AT PENNSYLVANIA RAILROAD STATION EXCAVATION

And this is what rapid transit is now doing for Manhattan. God forbid that it be the final solution of the problem of living in New York. So far as the rock drill is aiding in the present upbuilding it has little claim to popular gratitude. The work of rapid transit has hardly begun. The population must ultimately be distributed over a vastly greater area. The places of abode for the masses must have at least more of the possibilities of living in health and decency and comfort. The rock drill and the air compressor, both of them specially and distinctly New York institutions, have their work cut out for them for many years to come. Rapid transit is to be not merely a local affair, but must reach out far enough and with ramifications sufficiently numerous to make the home life and the growth in good citizenship through normal conditions of living at least a possibility.

The improvements we have been speaking of are being carried on and the tenements of the class indicated are being erected by wholessale on Manhattan Island about 10 or 11 miles from the City Hall, only 6 miles from the City Hall, and upon one of the surface lines of "rapid transit" across the bridge, we have the style of land occupation indicated by Figs. 13 and 14. Where they do undertake to pack them closer we have the two-family houses as in Figs. 15 and 16, the upper floors of

FIG. 33.—ROCK DRILLS AT THE PENNSYLVANIA RAILROAD STATION EXCAVATION

which, "six rooms and bath," now rent for $16 per month and upward. Rapid and long-reaching transit, entirely underground in Manhattan and using the numerous tunnels which the rock drill and the air compressor are rapidly pushing under the rivers, can open up to the teeming population of the city unlimited areas where all may live with good air to breathe and room to stretch their limbs. The future life and growth of the city are thus dependent to an incalculable degree upon the unceasing activities of the rock drill and the air compressor.

FIG 34.—PENNSYLVANIA RAILROAD EXCAVATION

The work of the rock drill in New York has been valuable in other lines of city development and improvement and with results wholly admirable and beneficent. Indeed it is not easy to suggest any public work in which the rock drill is not active and prominent. The Speedway is a New York institution and very largely a rock-drill creation. It was only a few years ago that a sudden and determined attempt was made to seize a wide strip of Central Park to be prepared and used for a driving track where fast horses might be speeded without restraint. This, in the popular view, was an outrageous proposition, although the entire desirability of such a speedway was conceded. It was a happy suggestion of some one to convert the shabby and worse than useless bank of the Harlem River into the track desired, and the result, only made possible by the rock drill, was most gratifying, not only to the owners of trotters and pacers, but to all who are glad to be mere spectators of equine displays and to all who have a pride in the city's special attractions.

The photographs show the mark of the rock drill in this construction and require little comment or explanation. Fig. 17 is taken near the southern entrance to the Speedway. The rock here extended to the river side of the road, although the cutting at the right does not appear in the picture. The Jumel mansion, once Washington's headquarters and now the property of the city and open to the public, is seen on the top of the hill. Fig. 18 shows the rock cutting below High Bridge, and Fig. 19 the heavy cutting above Washington Bridge. The most exciting brushes on the road usually occur near here. Fig. 20 shows the entrance to one of the subways which have been constructed to enable pedestrians to pass from one side of the Speedway to the other in safety and without interfering with the sport. This passage is,

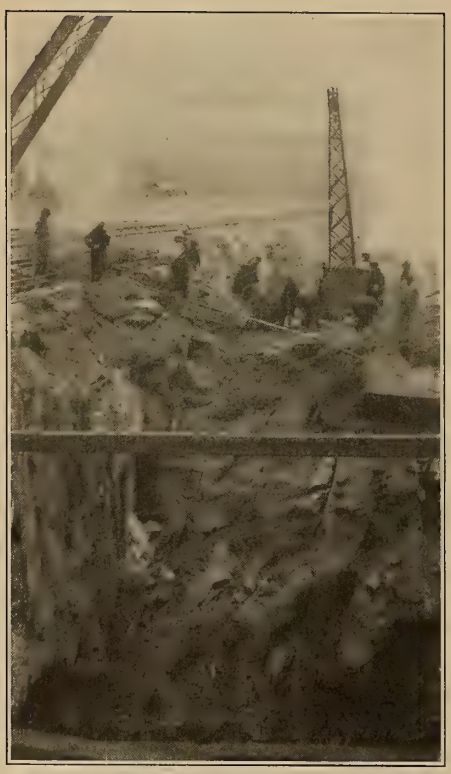


FIG. 35.—NEW YORK CENTRAL STATION EXCAVATION

of course, mostly cut out of the rock.

A couple of miles above the Speedway is the Harlem River Ship Canal. The Harlem connects the Hudson, or North, and the East Rivers and completes the insulation of Manhattan. The portion of the Harlem approaching the Hudson was narrow and tortuous, and, at least in recent years, entirely unnavigable. The ship canal is a waterway cut entirely in solid rock, "Marble Hill," as seen in Fig. 21. It cuts off the worthless portion of the Harlem and completes a broad channel of sufficient depth for commerce, transforming the entire river from an offensive sewer into an important and valuable waterway. The Hudson River Railroad has recently cut further into the face of the rock shown and has laid its passenger tracks there, shortening its line three-quarters of a mile and eliminating seven grade crossings. This ship canal was a big job for the rock drill.

The construction of the magnificent Riverside Drive, with its picturesque vistas of the Hudson, did not involve much heavy work for the rock drill and the rock faces left have already mostly been obliterated by subsequent building operations. On the Lafayette Boulevard, a valuable extension of Riverside Drive, we still can see the rocks as in Fig. 22. Central Park has four sunken cross-roads used for general traffic and entirely avoiding the park itself. These roads furnish us such samples of rock work as in Fig. 23, which is a bridge for one of the park driveways cut out of the solid rock, the sunken cross-road passing under the bridge.

One of the most picturesque and enjoyable trolley-car rides of New York is that from the 129th street ferry up over the palisades to Englewood, Hackensack and Paterson.

FIG. 36.—EXCAVATION WORK AT THE NEW YORK CENTRAL RAILROAD

FIG. 37.—HAND DRILLED CUT AT FORT WASHINGTON, H. R. R. R.

The cutting into the face of the palisades for the turn of the zig-zag road midway of its climbing, Fig. 24, was another achievement of the rock drill.

New York building operations demand enormous quantities of crushed stone for concrete, and a flourishing and persistent industry along the palisade waterfront is the preparation of this stone. There has been great popular outcry against this destruction of these picturesque, rocky battlements, and indeed with good reason. It is to be remembered, however, that the original vertical faces of these rocks are disappearing of themselves, the piles of crumbled débris in front of the faces, in many cases rising entirely to the top, so that none of the palisade effect remains. At least one rock-crushing concern can take to itself the credit of restoring rather than of destroying the palisades. Opposite Eighty-fourth street we have the picturesque bit seen in Fig. 25, where the vertical face of the rock now extends from the top clear down to near the water level, which can be found nowhere else along the river. This style of treatment extended far enough would restore the palisades as we may suppose they were long before the eyes of the present generation looked upon them.

Nothing has been said here of the home work of the air compressor. It is curious to note, however, that while the rock drill is pegging away for building foundations at the north end of Manhattan the air compressor finds employment at the extreme southern end in sinking caissons also for the foundations of buildings.

MUNICIPAL OWNERSHIP IN ENGLAND

By R. S. Hale

II.—MUNICIPAL OWNERSHIP AND OPERATION OF TRAMWAYS

In the first article of this series, Mr. Hale discussed the general conditions of the question, followed by a detailed investigation of public and private operation of gas and waterworks. This is followed, in the present issue, with a discussion of the much-agitated subject of the municipal conduct of public transport. The third and concluding paper will examine such undertakings as electric lighting and telephony, followed by a resumé of the entire question in the light of the several departments already treated.—The Editor.

NEXT, we come to the question of tramways, which, starting in 1860-1870, were built chiefly under the Tramway Act of 1870. The cause of this act was that when the municipal ownership idea first took hold in England in 1850-1870 it concerned itself, as is still the case to-day, not with starting new enterprises, but with taking over old ones from private owners, and, while, in many cases, the municipalities have done well even in taking enterprises at their market value, the very phrase market value implies that there is no very great profit to be made. In order that the municipalities might obtain a share of the profits of the tramways without running any of the risk, this act of 1870 gave franchises with the right for the municipalities to purchase after twenty-one years at the value of the plant alone. It should be remembered that in the case of roads, bridges, water and gas, the purchases had been at market value as going concerns, a feature to which no investor objects, except perhaps in the first few years of his business.

The whole question of terms of purchase and length of franchise is so important that we shall need to glance at a few of its most essential features. While purchase at any value, even as scrap iron, is better than the complete forfeiture provided for at the expiration of some franchises on the Continent of Europe, yet it is simplest to consider complete forfeiture first, i. e., what is the effect if the whole plant becomes the property of the city after a term of years. The managers in such a case will wish to lay aside each year a sum sufficient to repay the investor his capital at the end of the term. The money laid aside each year may be invested somewhere else to earn interest, and the necessary amount to be laid aside annually is shown per centum as follows:—

Years.		Earning Interest at Three Per Cent.	Earning Interest at Five Per Cent.
5	Sinking fund is.....	19.	18.
10	Sinking fund is.....	8.7	8.
20	Sinking fund is.....	3.7	3.
50	Sinking fund is.....	0.9	0.5

This brings out clearly the remarkable effect of time in questions of this character. To give fifty years' use of a property, even when money brings in only 3 per cent. is substantially equivalent to a sale.

If purchase, and not forfeiture is provided for, the amount necessary to be laid aside annually is, of course, less, but a right of purchase at anything less than the future market value is always worth something and requires some sinking fund even if, as in the case of the English Tramways Act of 1870, the terms provide for payment for the "then value" of the plant alone. An option to purchase at the future market value of the whole system is almost no option at all. It is merely an agreement that the owner will not be nasty, but will sell at a fair price, all things considered. While there is always a risk, still if the arbitrators are to consider

all the circumstances affecting market value, and if the sale is compulsory once it has gone to arbitration, this risk is as much in favor of the owner as of the holder of the option.

If, however, there is any circumstance that might affect the market value that is not to be considered, then the owner may, in the future, be obliged to part with his property at less than its value, and this option of difference, whether large or small, is a thing whose value must be earned by a sinking fund or by extra profits during the term of the franchise.

The difference between the market value and the various other values, such as plant value, replacement value, etc., lies in several items that I must spend a little time in considering, since many otherwise honourable people think that if an investor is given the value of his plant alone he is treated fairly. Everybody realizes, of course, that a dynamo is worth far more than the value of the copper and iron of which it is made. The labour of manufacture, the interest, depreciation and general expenses of the factory that made it, the cost of selling it, the freight and cartage to the point of erection, the superintendence and engineering expenses of its erection, the cost of testing it to see if it has fulfilled its guarantees, the interest on any payments that are made previous to the time it is ready to run, are all so clearly parts of the total cost that we need hardly spend time in discussing them. They can all be determined by noting at what price a contractor would undertake to deliver, erect and turn over complete and ready to run a similar dynamo, payment to be made in one lump sum at the time the dynamo is ready to run. It should be noted that the contractor will always, in making up his estimate of the price, include an allowance for contingencies and accidents, such as strikes or fires; further, if a general contractor should make a bid for a complete station of dynamos, engines, boilers, pumps, building switchboard, etc., etc. complete and ready to run he would take the bids of the various sub-contractors for each item, these already containing one allowance for contingencies, and after adding them together would figure the cost to him of the superintendence, engineering and contingencies while bringing together its separate parts and the interest on his various payments between the time each item was turned over to him and the time he could turn over the completed station and receive his payment. A still larger contractor who was going to make a complete installation of central station, track, overhead construction, car barns, etc., etc., would likewise have still another allowance for contingencies, superintendence, interest, etc., etc.

The fact that many of these expenses are referred to in accounts as "profit" is probably the reason that so many people do not regard them as items of cost, nevertheless, it is clear that they are really costs and not real profits, and no honest arbitrator in determining a cost would think of disregarding them.

Sometimes in starting a business or company many of these expenses are put down as so-called preliminary expenses, and in English practice, at least, it is customary to mark these off to profit and loss as soon as the earnings of the company permit. This does no harm where there is no legal limit to the dividends a company may pay, because, if a company has $100,000 to divide, it makes no difference whether this is called 5 per cent. on $2,000,000 or 500 per cent. on $20,000, but from a scientific point of view no expense of a company or business is so much a permanent asset, no asset depreciates less (so long as the business continues) than the preliminary expenses. If a business is to be wound up and discontinued, the preliminary expenses are, of course, worthless, but the case is similar to the freight or to the expense incurred in erecting a dynamo, since, if the dynamo is to be

moved to another place this portion of its cost becomes worthless. No competing business can start without exactly the same preliminary expenses (assuming, of course, that there was no waste) and both sets of investors should properly figure on earning dividends on the preliminary expenses just as much as on any other part of the investment, in fact, even more so, since any material thing will depreciate and be finally of no value; while so long as the business continues, the preliminary expense stands in the way of any competition and is of permanent value.

There are, however, certain other items that exist that are not as freely admitted as the above, and these are risk and development.

To bring out the feature of risk we may take, as an example, an oil well. A contractor will dig a well for, say, $5000, and turn it over ready for pumping. That is the cost of the well. Supposing, however, that, on an average, exactly one well in three strikes oil. It is obvious that if the owner of the land had an option to take over any well at its value, and value was considered the same as cost, that he would get no one to dig wells for him on speculation, since he would naturally take over only the good wells. The owner of the land could only get the wells dug if he put his option at three times the cost. If one well out of two may be expected to strike oil, he may put his option at twice the cost, and always in proportion to the risk. If the risk is absolute and known, the case is simple. If the risk is unknown, as in the case before any wells are dug, all that can be said is that the higher he makes his option price, the more wells will be dug, the lower the option the fewer wells, and if the option is at cost or plant value, no one will dig wells on speculation, even if absolutely certain to strike oil.

Of course, putting off the date of the option is equivalent to increasing its amount.

By using the table previously given, we can easily figure the result of postponing the option. If one well in three is successful, the digger pays out $15,000 for the three wells and must earn from the one successful well first, the normal interest rate on all his investment of $15,000, also $10,000 in addition against the time when all his property that is of any value is taken from him for $5000 the actual cost or plant value of the one good well. This means that to replace the $10,000 at the end of a ten-year's term, added to 3 per cent. on his original total investment of $15,000 earnings are needed of $1320 per year, and this is 26.4 per cent. of $5000. In other words, 26.4 per cent. per annum of the cost of the one successful well is necessary in such a case to give a genuine 3 per cent. on the real investment.

In such a case, unless the investor can earn 27 per cent. on the cost of the one successful well, he will do better to keep his money in the bank at 3 per cent.

Of course, if the risk is less, a less amount is required. If a greater risk, more is required.

It is often hard to realize what a risk was in the past, after time has shown the result.

To-day electricity for light or telephones are hardly regarded as of very great risk, yet in the time between 1875 and 1885, compressed air, hydraulic power, hot water at high pressure, and steam heating by pipes in the street were all being promoted, and had at that time as much apparent chance of success as electricity and telephones. If the principle be adopted that the successful plants may be taken over at cost, while the unsuccessful ones be left on the investors' hands, or rather in their profit and loss accounts, it is clear that the investing class, which is the class of people who save their money instead of spending it on their personal pleasures, must take this feature into account and must see a chance to collect from the citizens who use the successful ventures a sufficient

amount only to pay the interest on all the investments, but to make a sinking fund so that at the end of the franchises the investing class, as a whole, or on an average gets back all the investment.

Besides this item of risk, which is in addition to the contingencies of strikes, fires, accidents, etc., during construction there is a certain very essential feature which may be called development cost.

In certain businesses, as, for instance, cotton yarn, an investor builds a mill and as soon as the mill spins the cotton he can sell its output.

In other cases, however, the field must be developed. Take a railroad through a prairie. It will be years before that railroad can earn even its expenses and longer still before it can earn interest. If the investor sees a long life ahead he may figure, cost of railroad $1,000,000. Loss during first five years $500,000, compound interest on cost and losses during ten years another $500,000. At the end of ten years the railroad stands him in $2,000,000, or in other words, if he had not built the railroad, but had avoided his losses and saved the interest on his money he would have $2,000,000 in the bank instead of the railroad. The investor will not build that railroad unless he expects to have ten years from now something that will earn surely for all time 4 per cent. on $2,000,000, or 8 per cent. on $1,000,000 and, of course, if there is any risk he wants more still. If, however, the value of the railroad be figured at $1,000,000 and he is to be allowed to earn 4 per cent. or so on only $1,000,00 he will not invest. If the State has an option to take over the road at some future date at $1,000,000, then he must be allowed to tax the users of the railroad enough extra previous to the option coming into force, to pay, not only interest on the $2,000,000, but enough to repay the difference between the $2,000,000 of real cost and the $1,000,000 that he gets. If this is figured as a percentage on $1,000,000 it looks extremely high.

For instance, suppose the total concession is twenty years and it takes ten years before the road begins to earn a profit. Then for the last ten years the earnings must be 14.7 per cent on $1,000,000 to give 3 per cent on the real investment with no allowance for risk, and more than half of this is an unnecessary tax on the citizens who use the road during these years.

It must be remembered that this cost of development is in addition to risk and if there is a risk that after spending $2,000,000 on the road and initial losses, the road can earn nothing, the investor must look forward to a chance for an even greater profit to warrant investing. The idea that losses should in some cases properly be charged to capital account is perhaps more obvious if we remember that in a newspaper business all the losses of the first three years are considered part of the capital investment, and a newspaper business is no different in principle from any other, so far as accounts are concerned.

Another feature of the limited franchise must also be considered and that is the case of a growing business. In the case of a bridge, for instance, the investment is clear and definite and is all made at once, and even if the traffic takes time to develop, no fresh investment is necessary later. In the case, however, of other businesses, such as electric light, the call for new capital is incessant. The first investment is necessarily a one-sided one, a large station and a reasonable amount of mains to supply a few customers. The investor may see enough profit ahead to make his interest and sinking fund on the first investment during the life of the concession. Each customer that comes on requires, however, the investment of fresh capital, at least for a house connection and meter, often for a new main, at times even for a new station. As the end of the concession draws near, the necessary percentage for sinking fund on the new

capital grows larger and larger, until, in the last few years, the investor can make practically no investment that requires either risk or time for development, if he is to sell for anything less than the market value.

Each case varies, of course, according to the terms of the concession and the price that can be charged for the service. Take, for instance, a service where a maximum price is fixed and where the concessee is obliged to serve anybody at that price. If in the last few months of that concession he be required to invest new capital, it will be at a dead loss. Such terms would not be onerous at the beginning of the concession, but would be very onerous at the close.

I have above tried to bring out certain features of limited franchises:—

1. They always require a sinking fund that is very large for short terms, very small for long ones.

2. The sinking fund is very large if the option or terms of purchase at the end of the franchise are hard, and small if they are liberal.

3. These sinking funds are to be collected from the users of the service. If they are taken from the investor he will not invest.

4. The limited franchise bears very hard on enterprises that are risky and take time to develop and is easy on safe enterprises, or enterprises that can begin to earn the moment they are started.

5. A limited franchise of any growing business checks development very seriously as its term draws to a close.

I have spent time in bringing out these features. They are merely mathematical results, but they are so often not appreciated that it is worth while to restate them here in order that the effect of the English purchase clauses may be understood.

It is particularly necessary to state them since while the average citizen often does not appreciate them at all, even the investor appreciates them only as a whole.

The investor does not figure out all the items such as the risk, the time for development, the possible profits and the sinking fund separately and mathematically. What he does is to take a given proposition, and, after weighing it as a whole, decides to go ahead or not. It makes no difference to him what form the franchise takes, so long as he sees his profit and the investor does not much care, so long as he sees his real 4 per cent. or 5 per cent. (which is often an apparent 15 per cent. or more), whether the form of the franchise is advantageous for the public or not. The investor does not particularly care whether he is to charge $1 and pay a 10 per cent. tax, or charge 90 cents and pay no tax.

It is, however, important for the welfare of the community that public services should be encouraged, not checked. Forcing the investor to charge the user of the service anything in the way of sinking fund, or extra profits during the early years is not good public policy.

It should be noted here that the attempts by American municipal and legislative bodies to reduce rates involve the same principle as the purchase clause.

[Regulating rates so as to prevent discrimination between individuals or localities is an entirely distinct matter from reducing or increasing the general level of rates.]

The general level of rates is what determines the percentage of earnings on the investment, and if the legislature regulates rates so as to limit the net profit to the investor, it is obvious that this will have the same effect as would the exercise of a purchase clause at less than market value, since it makes little difference to an owner of property whether it is taken from him at less than its value, or whether it is left in his hands, but reduced in value. Such regulation would be far worse than a purchase clause since it may be put into effect at any time without notice.

Making a bargain as to rates at the initiation of an enterprise, or giv-

ing any new privileges in return for a reduction of rates is an entirely different matter.

We may now return to English tramways and look at the effect of the law of 1870. This law provides for twenty-one years' franchises with payment at the end for the plant alone, but with no allowance for risk or development.

The municipalities, however, were allowed to build the lines with no such purchase clause (as they themselves were the potential purchasers). They were not until about 1885 allowed to operate themselves, but could lease the lines.

Tramways, therefore, furnish from 1870 to about 1890 no comparison at all between municipal and private operation, since all the operation was private. As regards comparison between municipal and private enterprise, private enterprise was handicapped with the purchase clause that was absent in the case of municipal enterprise.

Now, as we have seen, the purchase clause is of comparatively small importance in the cases where the risk is small and the business is developed or needs no time for development as would be the case for tramways in the central portion of large cities, and such tramways were immediately developed, partly by municipal, but chiefly by private enterprise.

For instance, in 1880, although municipal enterprise was free to build, and private enterprise was subject to the tax of limited franchise, yet municipal enterprise had built only 35 miles of tramways as against 333 miles by private enterprise. Further, much of the municipal mileage was built only when private companies were found that would take leases on terms that practically relieved the municipality from all risk.

The purchase clause, however, is very onerous if there is any risk, or if it takes any time to develop the business. This would be the case in the outskirts of a town. In the outskirts, therefore, the purchase clause acted as a still greater deterrent to private enterprise, but there was no purchase clause to affect municipal enterprise. In spite of the perfect freedom for municipal enterprise the outskirts were not developed and English tramways became local short-distance affairs, tramways over 5 miles being even to-day the exception rather than the rule. (See Parliamentary Reports on Tramways and Light Railways.)

By 1880-90 the business had been enough developed so that the risk had to some extent disappeared, but by this time the concessions were drawing to a close, and on account of the short time remaining the purchase clause was fully as onerous as before and prevented private enterprises from extending their lines. The purchase clause, however, did not apply to the municipalities, nevertheless the municipalities did not develop the business even along horse-car lines.

In 1880-1885 electric traction appeared and it is interesting to note that one or two short lines were built in England and Ireland several years before the United States took it up, but in England in 1885 the purchase clause acted to check private enterprise in electric traction, both as regards risk and short tenure, and also as regards losses during development, since with only a few years of the concessions remaining, the companies could not afford to give up the profits during the time of change from horse to electric traction. None of these features applied to municipalities, which, by that time, were beginning to operate tramways. Even in the case of leased lines the cities could have undoubtedly changed their own horse-tramways to electric by suitable arrangements with the leasing companies, unless they insisted on the companies standing all the risk. This, however, was just what they did do, and the result was that it was not until 1895-1900, or perhaps ten years later than in the United States, that the change really became general.

The history of tramways in England, therefore, was that private enterprise refused to develop the business under the purchase clause unless the purchase clause was a liberal one, requiring only a small sinking fund, and that the municipalities did not develop the business at all except where there was absolutely no risk.

At the expiration of the twenty-one years' tenure the municipalities in many cases took over the franchises at the value of the plant, and as a result acquired the business at less than its real value. During the previous twenty-one years' term of private operation the companies had had to earn interest, not only on the real value, but in addition, a sinking fund, or else extra profits to compensate for the loss when the cities exercised their option. As a natural result, when the municipalities took over the business, they were able at once to reduce fares, improve the service and to show good profits on the cost to them. These profits have been concealed, in many cases, by the change from horse to electric traction, since it must be remembered that the cost of preliminary expenses, contingencies and development, whether for starting an enterprise or changing horse to electric traction exist just as much in the case of a municipality as for a company, and when a municipality is forbidden to charge these to capital account it has just the same effect in concealing the earnings as for a company. Note, however, that so long as a company is not limited in dividends and is not subject to a purchase clause at an unfair value, it makes no difference in dividing the profits whether they are figured as a percentage on a large or small capital, and note also that the municipality itself is not subject to any purchase clause.

The municipalities, likewise, seldom figures risk, even if it exists, but by reason of municipal delay and supineness few risky municipal enterprises have been undertaken, except such as working-class dwellings, baths, etc., where, if there is a loss, it is put in the same class as the expenditures on hospitals, poor relief, museums, education, etc., etc.

I consider, therefore, that the present municipal tramways are giving very much better service than the private ones, but that this is due to the tax on private enterprise from which the municipalities have always been free, and that much of the present cheap municipal tramway service is due to having to pay interest on much less than the real value of the plant.

The tax on private enterprise and the lack of municipal enterprise have limited and checked tramway development, so that millions of Englishmen, who, if they were in the United States, would live in the suburbs, here have to live in the slums; but those for whom the municipalities does provide tramways, ride comfortably and cheaply. No tramway companies in England have made tremendous profits. It is not that anyone else has got the profits that the American street railways have earned, but merely that no one has earned them at all. The work has been left undone.

In England the municipal tramways, so far as they go, are doing fully as well for the public as the private ones. It must be remembered, however, that all private fares must be high enough to allow for the sinking fund or extra profit that is to take care of the risk and of the development cost at the end of twenty-one years or less, while municipal fares are, in most cases, based on the acquirement by the municipalities of the private-built lines at far less than their market value.

During the last few years, prior to the purchase clause coming into effect, the company will, of course, squeeze out the last cent, and when the city takes over the plant at plant value, with no risk, the city can at once lower fares and start development. It must be remembered that by the Tramway Act of 1870, if the

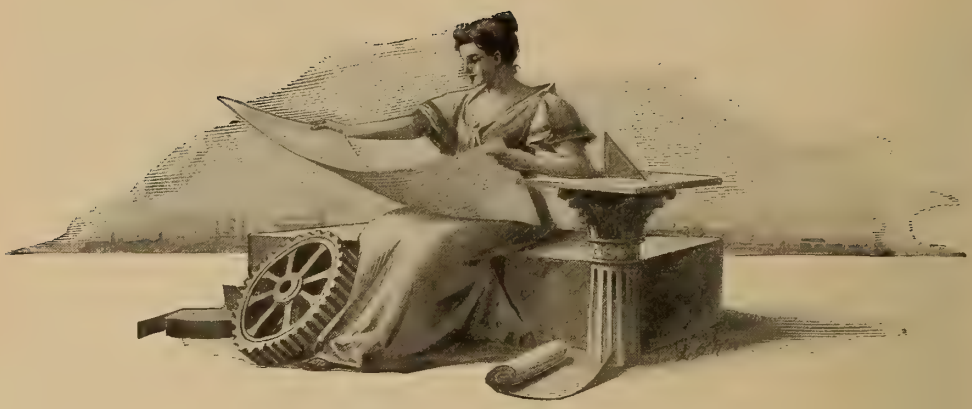
city does not exercise its option after twenty-one years, it has another option seven years later, obviously for too short a time for the company to take any interest in development. These features fully explain any apparent superiority of the existing municipal tramways compared with private.

As is well known, however, English tramways, except in one point, are so far behind American street railways that it is like comparing a baby with a grown man. The sole point of superiority in the English tramways, if it be a superiority, is that they make a short-distance rate of ½d. or 1 cent as compared with the minimum fare of 5 cents in America. English fares, per average mile traveled are higher, and English service poorer in spite of the lower wages paid in England.

The most interesting and valuable feature of English results is, however, the fact that after experimenting with a twenty-one years' franchise in the law of 1870, they passed in 1896 the Light Railway Act, practically a new tramway act, making the concessions in some cases for forty-two years, but the terms of purchase far more liberal, and in some cases making the concessions perpetual.

As we shall see later, their experience with electric light has led them to exactly the same action of giving up the limited franchise in favor of perpetual ones. It should be noted, however, that these perpetual franchises do not give the investor a free hand to make the price what he pleases or to give poor service. In the perpetual franchises the price to be charged for the service is carefully limited, the interests of the public are looked out for by means of the sliding scale and similar perpetual ones that are now being granted is merely in the line of making terms so that the present users of the service need not be taxed to make up for the loss that would be caused by the exercise of a purchase option at less than market price.

(To be continued.)



Current Topics

AMONG the important engineering exhibits at the St. Louis Exposition in 1904, one of the most interesting and valuable was undoubtedly the locomotive testing plant installed and operated by the Pennsylvania Railroad Company. The report issued by the Railroad Company, covering the data and results of the tests made upon American, French, and German locomotives, is itself a portly volume, forming a most valuable addition to the literature of locomotive engineering, and the results of the work conducted at St. Louis have already influenced locomotive design to a material extent.

Since the close of the Exhibition the testing plant has been removed from St. Louis to Altoona, Pa., where it is now erected in complete working order in the regular service of the Pennsylvania Railroad Company. The illustration gives a general idea of the arrangement of the plant, the construction being practically the same as at St. Louis, modified by the experience gained during its operation at the Exposition. In its present home the plant is installed in a building of brick and steel, especially erected for its reception, and provided with facilities for the handling of coal and the removal of ashes, together with water supply, and the manipulation of the apparatus is made more convenient than it was in the plant as installed at the Exposition.

In general, the plant consists of supporting wheels so arranged that they can be adjusted beneath the driving wheels of the various types of locomotives to be tested, these supporting wheels being provided with dynamometer brakes to oppose the proper resistance to the power of the engine. When under test, the locomotive exerts its drawbar pull upon a traction dynamometer, so that the power developed by the engine is accurately measured, this dynamometer being arranged with a recording apparatus, giving automatic diagrams of the pull, as well as the speed, while at the same time a mechanical integrator automatically sums up the work performed by the locomotive in foot-pounds.

As the coal and water can be accurately weighed and measured, and indicator diagrams taken continuously during a test, all the data required for a precise determination of the performance of a locomotive can be obtained, and the actual behaviour of various devices and types of construction ascertained.

Since November, 1906, the plant has been in regular operation at Altoona, its conduct requiring a force of sixteen men, and about three tests per week have been made, showing the practical usefulness of such an installation.

The development of the locomotive

THE PENNSYLVANIA LOCOMOTIVE TESTING PLANT AT ALTOONA

testing plant is an interesting growth from the experimental laboratory equipment devised many years ago by Professor Goss at Purdue University, and its adoption as a portion of the regular working equipment of a great railroad system is a tribute, both to the originator of the method and to the practicability of the idea. It is undoubtedly true that the continual improvement in the performance of the stationary engine has been largely due to the extent to which tests and investigations of efficiency have been possible. Road tests of locomotives have been made under various conditions, but the difficulty experienced in securing reliable simultaneous data as to speed, power developed, fuel consumed, and steam action in the cylinder, has rendered such trials of little practical value. The stationary testing plant, on the contrary, eliminates all the extraneous difficulties involved in measuring and recording the several elements of which locomotive performance is composed, so that for purposes of testing the locomotive is in the same position as the stationary steam engine.

There is no reason why the same method may not be applied to electric locomotives, and thus bring the comparison of the two systems upon a scientific basis.

THE *Dreadnought* has completed her preliminary cruise of 10,000 miles. The voyage from England to Gibraltar and thence to the West Indies was undertaken in order to supply the British Admiralty with data as to the performance of the ship under various sea conditions, the efficiency of her engines and boilers, and the wisdom of adhering in later designs to the disposition of armament. This battleship, marking a revolution in naval construction, has excited world-wide attention, and she has been frequently referred to as embodying the lessons of the war in the Far East. In a sense this is true. This all-big-gun-one-calibre ship dates back, however, six or seven years. The idea occurred first to Sir John Fisher when he was in command of the Mediterranean squadron between 1899 and 1902, as Lord Charles Beresford, who was then second in command, stated some years ago. The general lines were worked out in considerable detail on board the battleship *Renown*, which was then the British flagship, and when Sir John Fisher returned to Whitehall as a member of the Board of Admiralty the ship in all essential respects existed on paper. A committee of design was appointed, and to this body was submitted the rough

scheme, which included an armament of twelve 12-inch guns on a displacement of 18,000 tons. Careful experiment showed that not more than ten of these big weapons could be mounted with advantage, and even for this armament a displacement of 18,900 tons was essential if provision were to be made to obtain the specified speed of 21 knots together with adequate armour protection. On these lines the ship was finally designed by Sir Philip Watts, who introduced a number of novel features, not the least being the determination to place the officers forward and to divide the vessel by a series of bulkheads without intercommunicating doors. Special attention was also devoted to the under-water portion of the hull, with a view to minimizing the effects of explosion of floating mines or torpedoes. Once the Admiralty had decided to build such a colossal ship, it was determined to endeavour to get the vessel built in record time and in absolute secrecy. This attempt proved successful, owing to the loyal co-operation of the officials and workmen at Portsmouth Dockyard and the contractors, notably the makers of the machinery, Messrs. Vickers, Sons & Maxim, of Barrow-in-Furness, The fact that this vessel of a revolutionary type was being secretly constructed occasioned a great deal of consternation abroad, because it was at once realized that the appearance of this ship in commission would largely render obsolete the tactical principles hitherto embodied in the typical battleship of 15,000 tons with mixed armament. The naval authorities at Washington were the first to realize the full significance of the movement, but their hands were tied by the timidity of Congress, and thus it came about that the *Dreadnought* was built and completed at Portsmouth and had started on her experimental cruise within a period of less than fifteen months, this remarkable result being accomplished before a single foreign prototype had been laid down.

THE *Dreadnought's* cruise was watched with peculiar interest because she was the first big man-of-war in which turbine machinery had been fitted. The Admiralty's decision to abandon the well-tried reciprocating engine was viewed by engineers with suspicion and distrust, and it must be confessed that the Admiralty's experiment was a bold one. It must not be forgotten, however, that the British naval authorities had not only already gained considerable experience with the turbine in small vessels, but had had the advantage of the very costly and elaborate tests made by Messrs. John Brown & Co. in connection with the construction of the turbine driven Cunard liner *Carmania*. The reports received at the conclusion of the *Dreadnought's* voyage of 10,000 miles are not only a tribute to the capacity of the Parsons turbine, but to the character of the work of the great Barrow firm. In spite of idle stories which have been circulated, the *Dreadnought* has proved a triumphant success. During her long absence from England she was subjected to most exhaustive trials at various speeds, and her tactical qualities have been found in most respects to be even superior to those of battleships fitted with the reciprocating engines. The *Dreadnought* is guaranteed to be handy in manœuvring at all speeds, but owing largely to her size she is not so readily brought to rest, and it may be in this respect the turbines contribute in some slight measure to the defect. This is the only fault which is found with the new ship, and it is one which will be exaggerated in the heavier ships of other Powers because the greater the weight of displacement the greater the momentum. Throughout the cruise the turbines worked smoothly and well, but some slight rearrangements in connection with the ventilation of the engine room may be carried out as the result of experiments during the cruise. The heat, however, even in the

tropics, was not excessive. Throughout the cruise an average speed of about 17 knots was maintained without the slightest difficulty or inconvenience, though one of the boilers was rendered useless early in the voyage owing to the bursting of a tube. The ship, it may be added, was fitted with Babcock & Wilcox boilers. Even now that the *Dreadnought* has returned to British waters to take her place as flagship of the new Home Fleet, it is intended to carry out further experiments with a view to throwing light upon several technical problems to which attention has been drawn since the original design was prepared.

UNDER the new British programme of 1906 three more *Dreadnoughts* have been laid down, and in new estimates which will be finally discussed in the House of Commons in July next, it is proposed to lay down three more *Dreadnoughts,* or two only in the unlikely event of The Hague Conference agreeing to a limitation of armaments. These latest vessels will be an improvement upon the original type of ship. They will displace about 18,500, and will carry an improved design of gun, but whether the new gun will be a 12-inch weapon of fifty instead of forty-five calibre, as in the past, or whether it will be a piece of 13 inches or 13.5 inches, has not been officially stated. It is known that experiments of a confidential character are now in progress. It has been decided in place of the 12-pounder, quick-firing guns carried in the *Dreadnought* for repelling attacks by torpedo craft, to mount a weapon with greater capacity for stopping the onrush of such swift vessels in times of war. The general characteristics embodied in the *Dreadnought* will be repeated. All the main transverse bulkheads below the main deck will be unpierced, except for the purpose of conveying pipes or electric wires, and lifts will be provided to give access to the various compartments. It is understood, however, that an improved construction of the underwater part of the hull has been decided upon, with a view to the obtaining increased immunity from explosion of mine or torpedo. In modern design the aim is to provide an upward escape for the gases caused by explosion, and it is reported that these new "improved *Dreadnoughts,*" as well as the *Temeraire, Superb* and *Bellerophon,* of the 1906 naval programme, will have some form of outer casing to the hull providing an upward outlet for all gases. Like all British men-of-war now under construction these improved *Dreadnoughts* will be fitted with turbine machinery and water-tube boilers, and will carry a large quantity of liquid fuel, as the experiments already carried out have completely justified the Admiralty's views on this matter. Two of the ships will be laid down at Portsmouth and Devonport Dockyards, respectively, towards the end of the present year, and unless The Hague Conference comes to an agreement for the limitation of armaments the third vessel will be commenced in a private yard in the early months of next year. Consequently, next spring the position of the British fleet in respect of vessels exceeding a displacement of 15,000 tons, the normal size of the old type of most armoured ships, will be as follows:—

Class.	No. of Ships.	Displacement.	Guns.	Speed.
COMPLETED.				
King Edward VII	8	16,350	4 12-in, 4 9.2-in., 10 6-in.	18.9
Dreadnought	1	17,900	10 12-in.	21
Lord Nelson	2	16,500	4 12-in., 10 9.2-in.	18
Invincible	3	17,250	10 12-in.	25
Bellerophon	3	18,000	10 12-in.	21
FIRST STAGE OF BUILDING.				
"Improved *Dreadnought*"		18,500	10 12-in. or 13 5-in	21

It may be added that these ships will be distributed as follows among the government and private building yards of Great Britain:—

Lord Nelson Class—*Lord Nelson*, Palmer Shipbuilding Company, Jarrow-on-Tyne; *Agamemnon*, Messrs. W. Beardmore & Co., Glasgow.

Invincible Class—*Invincible*, Sir W. G. Armstrong, Whitworth & Co., Newcastle-on-Tyne; *Inflexible*, Messrs. John Brown & Co., Glasgow; *Indomitable*, Fairfield Shipbuilding Company, Glasgow.

Bellerophon Class—*Bellerophon*, Royal Dockyard, Portsmouth; *Temeraire*, Devonport Royal Dockyard; *Superb*, Sir. W. G. Armstrong, Whitworth & Co., Newcastle-on-Tyne.

Improved *Dreadnought*, 1907-1908 programme — One at Portsmouth Royal Dockyard; one at Devonport Royal Dockyard; one (if built) by private contract.

IT is claimed that in the matter of wireless telegraphy the British Navy is ahead of all rivals. The British Admiralty were the first to adopt this means of communication, and this enterprise was largely due to the present Controller of the Navy, Rear-Admiral Sir H. B. Jackson. This officer was in command of one of the technical training schools of the Navy, investigating independently a system of wirelesss telegraphy, when Signor Marconi suddenly produced his apparatus. The Admiralty adopted the Italian inventor's system, and it was immediately installed in a large number of ships and great attention was devoted to its study with a view to its improvement. Two years ago, in view of Admiral Jackson's scientific attainments, he was appointed Controller of the Navy, and from that day wireless telegraphy for naval purposes has developed under his initiative with extraordinary success. At first it was viewed by the older officers of the fleet with some distrust, owing to the difficulty of control and the extreme delicacy of the apparatus. It was held that in its then state of development it would be useless in war time, because an enemy would be able to pick up messages sent out from British ships; or, on the other hand, would be able to send out other ethereal waves which would disorganize British communications. In consequence of the patient labours of Admiral Jackson and other officers, these disadvantages have largely been removed, and the apparatus which is now being fitted in British ships is very much simplified, and a system of "tuning" has been perfected which, it is claimed, ensures absolute secrecy and certainty of communication. In view of the progress which has been made, some members of the House of Commons were nervous as to the effect of the agreement arrived at by the recent radio-telegraphic convention. This agreement provides for intercommunication of systems under certain specified conditions, and it was feared that it would affect the British naval arrangements adversely. Four years ago the Admiralty signed with the Marconi Company an agreement, to run for eleven years, under which the British naval authorities obtained the use of Marconi's apparatus and any new patents in return for a payment of £20,000 and an annual subvention of £5000. The fears which were entertained as to the influence of the convention upon the development of wireless telegraphy for war purposes appear to have been groundless. Official assurance has now been given that the convention will not affect the war arrangements of the British Navy, while the policy of intercommunication between various systems may lead to a great development of wireless telegraphy between various parts of the Empire.

WILLIAM LAWRENCE SAUNDERS

By F. W. Iredell

WILLIAM LAWRENCE SAUNDERS, president of the Ingersoll-Rand Company, was born at Columbus, Georgia, November 1, 1856. His boyhood was spent at Apalachicola, Florida, where his father, Rev. William Trebell Saunders, D. D., was rector of Trinity Protestant Episcopal church.

In 1872 Dr. Saunders went with his family to live in Philadelphia. William thereupon entered the Scientific department of the University of Pennsylvania. He was a good student, distinguishing himself in many ways, and receiving many honours. He showed marked ability as a writer, debater and public speaker. He was moderator of the Philomathean Society, editor-in-chief of the University Magazine and Class Poet. He was graduated in 1876 from the mining engineering section of his class.

After graduation Mr. Saunders' literary bent led to his doing special reporting for one or more of the Philadelphia papers. During the Centennial Exposition he made two ascensions from the exposition grounds with Prof. King in the huge balloon "Buffalo." On one of these occasions the balloon remained up all night and attained a height of three and one-half miles. Alfred Austin, the present Poet Laureate, at that time the correspondent of the London Times, was one of the company.

In the spring of 1878 Mr. Saunders took up the practice of the engineering profession, entering the service of the National Storage Company at Communipaw, N. J. He made a series of soundings in New York Bay preceding the erection of the National docks and the excavation of the ship channel to the docks. Later he had charge of the construction of the piers and warehouses and the dredging of the slips and ship channel; also engineering charge in building the Eagle refinery.

In cutting the ship channel a ledge of rock was encountered and subaqueous drilling and blasting were begun. Great difficulty was experienced in keeping the drills from blocking in the holes; but, after many experiments, Mr. Saunders devised and patented the apparatus now in general use. In this method the drill works inside a large tube which rests solidly on the surface of the rock. A small pipe conveys water under pressure from a pump on the drill stage to the bottom of the hole and the current thus induced carries away the chippings made by the drills.

In 1882 Mr. Saunders accepted the post of engineer of the Ingersoll Rock Drill Company, and was sent to Vermont to develop a channeling machine. After some months of observing, experimenting and building, Mr. Saunders produced the Ingersoll Track Channeler and Gadder. This was followed by the Bar Channeler. Mr. Saunders took out a number of patents covering these and other devices which were eventually purchased by the Ingersoll-Sergeant Drill Company.

In 1884 Mr. Saunders visited Bermuda and investigated the feasibility of cutting a ship channel across the coral reefs to the harbor of St. George. These investigations were made personally in a diving suit. In 1898 he visited the Iron Gates of the Danube to inspect the working of methods of excavation which had been recommended by him to the Austro-Hungarian government engineers for the removal of these great obstacles to commerce. This was a vast undertaking, requiring six years for its completion, and extending over fifty miles of river length. In 1899 he visted Russia, investigating mining operations. He has since traveled

extensively both in this country and in Europe on professional missions. His latest diversion was a thorough investigation of the progress of the Panama Canal, followed by a hunting expedition for alligators.

Mr. Saunders has been a recognized authority on compressed air and machinery and methods for excavating rock for the past twenty years. He has been a voluminous writer upon these subjects, and since 1895 has published "Compressed Air," a monthly periodical devoted to his specialties. In 1902 he published "A Cyclopedia of Compressed Air Information." He had given much thought to the reheating of compressed air and has made exhaustive investigations and experiments leading to the development of an effective and economical "internal reheater." Some of his work in this line has been in co-operation with Mr. Thomas A. Edison.

On March 24, 1904, Mr. Saunders was made president of the Ingersoll-Sergeant Drill Company, an office made vacant by the death of Mr. William R. Grace.

In May, 1905, the Ingersoll-Sergeant Drill Company and the Rand Drill Company were merged into the Ingersoll-Rand Company. This was the culmination of several years' work by Mr. Saunders, supported by his fellow officers and directors, to harmonize the relations of the two companies which overshadowed all other competitors in the manufacture of air compressors and rock drills. The operations of Ingersoll-Rand Company have been most successful and illustrate to the purchasers of machinery the value of such combinations. Each company possessed patents covering features of pre-eminent value which are now interchangeable and applicable to the machinery of both companies, resulting in a marked advance in machine construction. Every shop of both companies is now working to its limit and employment is given to about 4500 men.

The social side of Mr. Saunders' life has been equally noteworthy. He takes an active interest in every public question. He is a fluent and forceful public speaker, a model presiding officer, a delightful toastmaster, an interesting lecturer, and, in former years, a highly intelligent and skilful actor in theatricals ranging from the farcial to the Shakesperian.

For eighteen years he has been a prominent and public spirited citizen of North Plainfield, N. J. Twice he was elected mayor on the Democratic ticket in a place overwhelmingly Republican. He was made president of Muhlenburg Hospital in 1899, and he has served on its board of governors for many years. He is a member of the Episcopal Church, has served long terms as vestryman, and is ever active and influential in its work.

Mr. Saunders is a hard worker, but he is never hurried. He accomplishes much while seeming at comparative leisure. He never gives a decision until he has heard the whole case; then he decides at once. He never does a thing twice. He never wastes time. He has a purpose and a plan for every hour, and when he has fulfilled his purposes and accomplished his plans, business or social, he goes to bed and sleeps to rise early in the morning and eager for the duties of the day.

Prominent among Mr. Saunders' characteristics are his love for and faith in human nature; his enduring, tenacious, unshakable friendships; his intuitive perception of every man's capabilities; his remarkable power of accomplishing results with whatever instruments happen to be available; his willingness to assume responsibilities, no matter how onerous; his keen, unfailing, buoyant sense of humour, and his high physical, mental and moral courage.

Mr. Saunders is a member of the American Society of Civil Engineers, as well as a member of the American Society of Mechanical Engineers, and of the American Institute of Mining Engineers.

ADOLF BENDER

PRESIDENT DE LA VERGNE MACHINE COMPANY

SEE PAGE 287

INDEXED

CASSIER'S MAGAZINE

VOL. XXXII JULY, 1907 No. 3

U.S. PATENT OFFICE LIBRARY JUN 29 1907

THE MANUFACTURE OF STEEL RAILS

THE INFLUENCE OF THE DRY BLAST IN BESSEMER STEEL PRACTICE

By James C. Bayles, M. E., Ph. D.

The interest in the subject of the breakages of steel rails in service continues, both in the United States and elsewhere. The thoughtful paper of Mr. Robert Job, published in our issue for May, considered one phase of the question, and emphasized the necessity for rigid inspection and proper heat treatment. In the paper here presented, the matter is considered from the viewpoint of the rail maker; and the extent to which he has been bound by the specifications of the railways, while held at the same time responsible for results, is clearly shown. The question is one which has several sides, and all should have ample publicity and critical discussion with the one object of securing greater safety for the traveling public and the prosperity of the community, so indissolubly connected with all that relates to successful transportation.—THE EDITOR.

THE analysis of physical defects found in steel rails on inspection, or developed by wear or fracture, presented to the readers of this magazine in the judicial paper of Mr. Robert Job (May, 1907), suggests an inquiry as to practicable methods for improving the Bessemer practice with a view to making better ingots.

No argument is needed to establish the contention that one reason for rail defects is that a great many are rolled from unsound ingots. Recent investigations point to the conclusion that to eliminate unsoundness it would be necessary for the Bessemer rail makers to "crop" from 25 to 30 per cent. of the ingot metal as now made. In the circumstances this proposition is purely academic. As Dr. Robert W. Hunt made clear in his recent discussion of this subject before the American Institute of Mining Engineers, such a percentage of rejection is impracticable from the point of view of the rail maker who conducts the business primarily for profit. Conceding this, as we must, the first of several questions of immediate practical interest is: Can Bessemer steel be cast into sound ingots with such uniformity in practice as to permit the rejection for rail purposes of every ingot in any respect unsound?

The life of the Bessemer process and the value of the plants equipped for working it, depend upon the answer to this question. The companies now manufacturing more than four millions of tons of Bessemer rails annually cannot, like the Chancellor at the court of the sleepy king,—"smiling, put the question by." The average man has to travel more or less, and rarely feels that his life

 Copyright, 1907, by The Cassier's Magazine Co., New York

is insured at its full value. The sensational statistics of broken rails disquiet him. Hence, the inquiry is pressed with disagreeable insistence and may finally reach Congress. The rail makers must answer it "Yes" or "No." If "Yes," it is incumbent upon them at once to have recourse to expedients by which piping, blowholes and segregation in rail ingots may be minimized or wholly avoided. If "No," public opinion will demand instant relief from the burden of a protective duty on rails imposed for the benefit of an industry which confesses that it has no right to exist as a source of supply for rail steel.

The subject is many sided, but for the purposes of this discussion the chemistry of iron mixtures for the Bessemer converter, if not dismissed from consideration, may be dealt with in the Parliamentary way, and "laid on the table." The formula which gives the best rails is the best formula to follow. In American rail-mill practice very little ground for just complaint has existed, or exists now, in causes discoverable by analysis, save those for which the railroads are themselves responsible. Somewhat wide departures from theoretical formulæ have been found not inconsistent with physical properties which have given rails exceptional life under severe traffic conditions. Indeed, we shall be better able to say with confidence what importance to attach to more or less of this or that item of the analysis, when we shall have eliminated causes of rail deterioration or fracture which have little or nothing to do with their composition.

It is a safe generalization that a sound rail cannot be rolled from an unsound ingot, no matter what it is made of. True, a perfectly sound ingot of ideal chemical composition may make a very bad rail as the result of abuse in heating, rolling, straightening, punching or other controllable causes; but, obviously a sound rail must start with a sound ingot. All sorts of things may happen afterwards, but that, as Kipling would say, is "another story."

In current Bessemer practice, ingot soundness depends upon causes only to a limited degree under control of the man who manipulates the blow. The mixer used in every Bessemer mill gives the nearest approach to uniformity in the composition of successive charges possible in any metallurgical operation conducted on a large scale. But the steel maker has two elements to deal with—the charge and the blast. Within the range of permissible variations one is probably as important as the other. One is practically constant; the other is as inconstant as the readings of thermometer and barometer.

The most variable of all the normal constituents of atmospheric air is water in the form of vapor. Its moisture content at, say, 60° F. is likely to range between 0.8 and 1.0 part per 100 parts, by volume, when no sensible humidity is observed,—but under a great variety of conditions it is liable to go very much higher. It approximates dryness at about 32° F. and becomes dryer as it is further chilled,—partly by the deposition of frost crystals and partly by an action comparable to the squeezing of a wet sponge. As its temperature rises, air, which is able to find it, takes up all the moisture it wants,—its capacity to absorb and hold it being, generally speaking, a function of its temperature. It should be remembered, however, that this law of the relation between the records of thermometer and hygrometer is somewhat elastic, since an air current may carry in suspension a great deal more water than is needed to saturate it. Everyone has observed this when exposed to a wind-driven fog, which, for some reason, refuses to dissolve in normal precipitation but is almost as wetting as rain, or when on the lee side of a cataract or a fountain. Under these conditions air may carry with it much more water than it could absorb and hold, and it often does exactly this. Fog is not always com-

posed of the microscopic globules which Tyndall humorously designated as "water dust." Sometimes these globules are of tangible proportions. De Saussure (in no way related to Munchausen) tells us that when caught in an Alpine fog he once saw "congeries of bubbles as large as peas" floating past him—an atmospheric condition which might have suggested the inquiry whether his environment at the moment was very moist air or highly aerated water. But leaving exceptional meteorological phenomena out of consideration and noting only what is of daily experience, the moisture content of air on a normal day, when the temperature is above the frost point, is liable to vary between 30 and 60 on the scale of comparative humidity, and through a normal week or month is quite certain to show a range of 20 to 100, plus more or less suspended visible or sensible vapor. This is the blast of the Bessemer converter. A very small part of its variability in the percentages of silicon, phosphorous, sulphur, manganese, carbon or any one of half a dozen elements normally or accidentally present in the converter charge, would leave it wholly uncertain whether the result of the cast would be tool steel or yacht ballast. Variability in the blast is an original defect in the pneumatic process. It was at first thought of less importance than has attached to it since the chemistry of the process has been refined to the present standard. This would be surprising, in view of the fact that it had long been part of the proverbial wisdom of the blast-furnace man that it was easier to make No. 1 pig in dry than in damp weather, were it not for the older phenomenon, equally proverbial, known as "the invisibility of the obvious." Nothing is more inexplicable, retrospectively considered, than the length of time one may look steadily at what he is seeking without seeing it. Every blast-furnace manager had observed with emotions ranging from surprise to consternation, that in what seemed to be mere caprice, his hearth temperatures will sometimes fall with unaccountable suddenness and give him a very undesirable grade of iron. Something very like this happens with disturbing frequency in the working of the Bessemer converter. The steel maker knows this is not due to variations in the composition of the converter charge. He has a continual, and presumably accurate, record of the contents of the mixer and thus knows exactly what he is blowing. What he does not know, since the hygrometer has not been introduced into his kit, is how he is blowing it. Variations in the composition of the mixer bath are bound to come about very slowly through withdrawals and additions, and are restricted within narrow limits. But his blast is as inconstant as Proteus of the fable. Its first function is to burn out the silicon, and then the carbon. In doing this, if everything is as it should be, he is likely to get his temperature so high that to regulate it for pouring the addition of scrap is necessary. But everything is not always as it should be. He has found, for example, that in weather conditions which give relatively high humidity, the temperature has a tendency to run down, and if he made what he considers the normal scrap addition to the bath, he would be apt to form sculls and "gob up" the neck of the converter. He might even find it impossible to pour his charge when the time came, and, at best, could make only defective ingots. If a given blow is sluggish and unsatisfactory, less scrap is added in the next blow, with the result that it may be too hot. In clear, cold weather, no trouble of this kind is experienced, but at other times the blower seesaws up and down the scale of temperatures, with his eyes for a thermometer and his judgment for a pyrometer, by recourse to the crude expedient of increasing or reducing his scrap additions. To this fact, probably more than to any other yet

recognized, are due the inequalities of Bessemer ingots in present practice.

The reactions of the converter are much too complex to permit any other confidence than what a great exponent of physical phenomena has described as "the confidence of half knowledge," as to just what would happen if any one condition was changed while the others remained constant. But all whose opinion is entitled to serious consideration seem to be agreed that results of great benefit would be attained if the blast was made as constant as the composition of the charge in Bessemer practice. The advantages to be expected from doing this were recognized a quarter of a century ago, but the convenient means were not found until James Gayley, one of the few accomplished and experienced technicians of the steel industry to reach the king-row of managerial responsibility, invented the method of minimizing and making constant the moisture content of a furnace blast by the simple and obvious expedient of refrigeration. In a word, he thus simulates by mechanical means the atmospheric conditions on a clear, cold day, when the moisture is said to be "frozen out" of the air and it is without sensible humidity. To effect this degree of dessication the air of the blast is drawn through an insulated chamber over and through coils of pipes in which is maintained a circulation of brine cooled by anhydrous ammonia. In passing through this chamber the moisture of the air is precipitated and deposited in white frost crystals on the cold pipes. Although this does not dry the air completely, a condition possible only at a very much lower temperature, the humidity is reduced to a negligible quantity and kept constant. Observations at the Isabella furnace, near Pittsburg, where this method of air-drying was first applied in blast-furnace operation, showed that the moisture in the blast was thus reduced to 1.75 grains per cubic foot, and that the amount of water abstracted from it averaged 69 pounds to the ton of iron, or 2,784 gallons in 24 hours. In summing up the results of the dried blast at the Isabella furnaces, Mr. Gayley, in his paper before the Iron and Steel Institute, said:—

"The application of the dry blast to the blast furnace shows, in addition to the economic effects, that the furnace can be controlled with precision; that it works with greater regularity, and that in consequence the product is uniform with respect to grade and composition, which makes the dry blast particularly valuable in making foundry iron, which is marketed by grade."

The effect of applying this method of blast drying to the Bessemer converter promises to be of first practical importance, nothwithstanding the fact that the chemists are not in full agreement as to how the expected benefits are to be brought about. There is little doubt, however, that it will begin the good work by eliminating the one element of acrobatic variability due to the constantly changing humidity of the atmosphere. So long as this accomplishes good results, it makes very little difference how. With a uniform charge, uniform heats, and a uniform blast it will be more easily possible than now to determine a good many disputed points in the chemistry of Bessemer steel. If an imaginative person, given to the dangerous habit of thinking aloud, should discuss this subject with himself, he might be overheard to say something like the following:—

"Suppose that a given quantity of water as vapour is carried by the blast into the converter and through the charge: What becomes of it? Obviously, it is instantly and perhaps explosively converted into superheated steam and then dissociated into its elements. Under these circumstances the free oxygen thus liberated would probably find its strongest affinity in the carbon; but as that diminished to the vanishing

point it might be expected to elect iron as its second choice and combine with it,—so much of it as was not dissolved by the manganese remaining in the charge as oxide of iron. Of course, the chemist will tell you that he never succeeded in finding oxide of iron in Bessemer steel, but if it was not there no doubt the steel would be very much better than it usually is. But, however this may be, the heat required to dissociate the steam is withdrawn from the charge at the moment when it needs to be hottest to attain the purpose of the blow. This is a distinct disadvantage. As to the free hydrogen, well, that might combine with sulphur or phosphorus if there was enough of either to occupy it, but it is more likely to remain to a considerable extent occluded in the metal, in which case it might explain a good many blow holes in the ingot that would not otherwise be there.

"Yes, I know that the chemist will tell you that he has never found any evidence of occluded hydrogen or nitrogen in Bessemer steel, but perhaps that makes no great difference. It is not easy to analyze a blow hole, and it may very well be that in getting ready to do it he has lost its contents and does not know any better than another what it contained when formed."

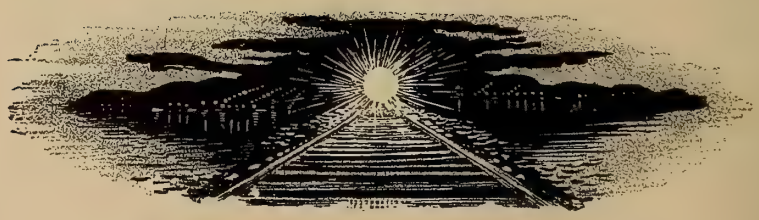
If anything like this should chance to be overheard, it is probable that any number of steel-works' chemists would be found ready to dispute it, but that must be expected. If experienced in such matters, the imaginative person will have learned better than to take the chemist too seriously. He means well, but of the steel man who depends wholly for his knowledge of steel making upon what the chemist can tell him, it may be said with truth that the breadth of his misconception will be equaled only by the comprehensiveness of his misinformation. Not being a metallurgical chemist I have no hesitation in admitting that I do not know just what are the reactions of the converter, and if I add that I doubt if any one else does I come dangerously near the truth. But I see good reason for believing that the Gayley dry blast will work such changes in converter practice as to make it possible to secure in the Bessemer rail ingot greater uniformity of desirable qualities than has ever been reached uniformly in the best open-hearth practice. This I regard as the first step in rail improvement.

The next step, in my judgment, should be the promulgation of a declaration of independence upon the part of the rail makers. They are now in a position to do this and to maintain it. What it is time for them to repudiate is the assumption of the representatives of the railroads of the right to prescribe every detail of composition and manipulation of rails, and then shift upon the makers the responsibility for any grounds of dissatisfaction which may develop in use. A typical rail specification leaves the maker no discretion as to carbon, phosphorus, silicon, sulphur or manganese. The section is exactly prescribed and the permissible reduction in cooling fixed. Probably there would be no objection to this from the point of view of the steel man if the railroad companies were satisfied with rails made exactly as they want them made, but they are not. Among other dangerous departures from former practice, which, it is insisted, was better than that now followed, they have gradually advanced the carbon percentage to .50, which, I believe, is higher than any European maker would become responsible for. What they have sought is hardness, with a view to a longer wear in service, but they have secured it at the sacrifice of the kind of toughness—for want of a better term—which in rails best resists the tendency to fracture under the shocks of traffic. In still other respects the requirements of railroad inspectors are opposed to the convictions of the rail maker. There was a time when competition made such a surrender

necessary. It is no longer so. The railroad engineers assume no part of the responsibility for a rail supply with which they are wholly dissatisfied. On the contrary, they pose as victims and the rail makers are denounced as indifferent to every thing except profit.

Well, perhaps the blame for the present situation may be equably divided. Undoubtedly more has been sacrificed to tonnage than reached the scrap pile as discarded machinery. Nothing is to be gained, however, by inconclusive recrimination. To reestablish itself in public confidence and respect, the Bessemer steel industry must do what its own best interests demand. As I have endeavored to show, the first step in this direction is to eliminate the variability in product inseparable from dependence upon a natural blast of fluctuating humidity. If the quality of the ingots thus made is not high enough, it will be because the mixture contains iron from ores carrying more phosphorus than the acid Bessemer process will tolerate. For these ores the United States Steel Corporation will probably have to build some new plants and change some old ones to make basic steel. This would permit the phosphorus in the acid Bessemer to be kept down to .08, and it will then be beyond open-hearth competition so far as rail ingots are concerned. Having accomplished this much, the time will come to standardize steel rail formulæ and sections.

Specifications from railroads, which the rail makers are unwilling to "stand for," if refused, will have to be modified. Public opinion will fully sustain the rail makers in refusing to sacrifice to longer wear the strength needed to resist breaking strains. American railroad engineers will bluster a good deal, no doubt, but they would have to take what they could get, especially as such rails as they now prescribe could not be had from other countries.



INCANDESCENT GAS MANTLES

By Harold Baron, B. Sc.

When electric lighting was first introduced commercially it was generally believed that gas lighting was doomed, and the price of shares in gas lighting companies fell greatly in view of the formidable competitor which had presented itself. The recovery soon came, however, and one of the most important factors in enabling gas lighting to hold its own against electricity was the invention of the incandescent gas mantle by Dr. Auer von Welsbach, thus enabling a far higher efficiency to be obtained than had previously been possible, together with the more powerful illuminating units. The production of incandescent mantles has now become an established industry, and the details and illustrations shown by Mr. Baron give an excellent idea of the various processes involved in the manufacture.—The Editor.

THE story of the incandescent mantle is one of the most interesting chapters in the history of industry. The discovery of the incandescent gas light by the Viennese chemist, Welsbach, ranks in importance with the epoch making discoveries of Watt, Faraday, Nobel and Parsons. What the incandescent mantel has done for gas lighting can never be calculated. The manufacture of mantles has now become an important and highly developed industry. The amount of capital involved and the number of work people employed has increased enormously in recent years. A few details concerning the present state of the industry, and the organization of a modern incandescent mantle factory may therefore be of interest.

It was not until 1891 that a really serviceable mantle was put upon the market and it was then somewhat dear. Nevertheless it met with success, and from this time forward the gas manufacturers have been able effectively to combat the keen competition of the incandescent electric light.

In the early years of incandescent gas lighting the various Welsbach companies were masters of the situation, but in 1894-95 a number of manufacturers came forward offering mantles at much lower prices than the Welsbach mantles. At first these mantles were not of particularly good quality, but on account of their low price they met with a ready sale and the original patentees found that they had very keen opposition to face.

In 1896 a judgment in the Imperial German Court sufficed to justify the competitors of the Auer Gesellschaft in prosecuting their manufacture and the monopoly previously maintained by this form was broken. This decision was of the utmost importance to the industry, and since that critical moment it has developed by leaps and bounds, until it has attained the great prosperity at which it stands to-day.

Whilst in the early days the mantles left much to be desired in the uniformity and quality of light, these relations were much improved by 1899; when mantles of various makes were on the market, which had an initial illuminating power of 80 to 90 candles and a consumption of about 1.3 liter (0.0459 cubic foot) per candle per hour. More recently the mantles have been greatly improved, owing to increased knowledge with regard to the rare earths and the textile fibres used in their manufacture.

For a long time cotton yarn was solely used in weaving or rather knitting the texture which forms the basis of the mantle. This produced an article of good appearance and uniform structure. There was, therefore, some difficulty at first in introducing ramie or china grass for this purpose, since it gives a mantle a much rougher appearance than the cotton mantle. But ramie possesses

KNITTING THE FABRIC FOR USE IN THE MANUFACTURE OF WELSBACH MANTLES

WASHING THE FABRIC FOR WELSBACH MANTLES.

certain advantages over cotton which makes it an admirable basis for the incandescent oxides, whereas the cotton mantle after a short time in the flame loses its shape, and diminishes in illuminating power, while the ramie mantle preserves its original form and, remaining in the hottest regions of the flame, emits an almost constant light. The diminution of candle power of a ramie mantle after a hundred hours of burning seldom exceeds 10 per cent., whereas the cotton mantle always degenerates more rapidly.

Ten years ago the incandescent mantle was a chemical speciality, manufactured in small quantities, with comparatively small capital, but nevertheless it was a fairly profitable undertaking. The work was mostly done by hand and no expensive plant was erected. To-day, however, a very large capital is invested in the incandescent mantle industry. It gives employment to many operatives and the daily production of mantles is enormous. A typical German factory, that of the Aktien-Gesellschaft für Gasglühlicht, employs 1500 persons About 800 kg. of ramie yarn is knitted up daily, and the daily turnout of mantles amounts to more than 200,000.

A short description of the operations carried out in this factory, to which author is indebted for the accompanying illustrations may be of interest.

The ramie yarn is knitted on special round knitting machines in the form of an endless stocking. An incandescent mantle is usually spoken of in Germany as a "Strumpf," which means stocking. This long stocking is then very carefully washed and cut up into pieces. It now passes into another department, where it is immersed in the fluid, which gives the mantle its most important property, namely, illuminating power. The chief constituent of this bath is thorium nitrate, a salt which is obtained from monazite sand found

DIVIDING THE KNITTED FABRIC INTO LENGTHS FOR MANTLES

CHARGING THE FABRIC WITH THE SOLUTION OF NITRATES

ROOM FOR DRYING MANTLES AFTER CHARGING WITH THE THORIUM SALTS

in Brazil. The bath also contains small quantities of cerium nitrate and occasionally other nitrates of the rare earths. The exact proportions of these constituents is a matter of the greatest importance upon which the success of the mantle depends. The constitution of this bath is therefore a jealously guarded secret.

The next operation is the burning off of the mantle, whereby the cotton forming the basis of the mantle is consumed and the salts are converted into oxides. This is carried out on special machines and the thorium oxide remains in the form of the original texture as a light structure of ash. On a second flame, the so-called press gas flame, the mantle is brought into the proper form for use. At this stage the mantle is in a very fragile condition and cannot be handled, much less transported, without damage. The mantle is, therefore, immersed in collodion, or some such fluid leaves the thoria covered with a film of readily combustible material. In this form, and carefully packed, the mantles are exported to America, Australia and all parts of the globe.

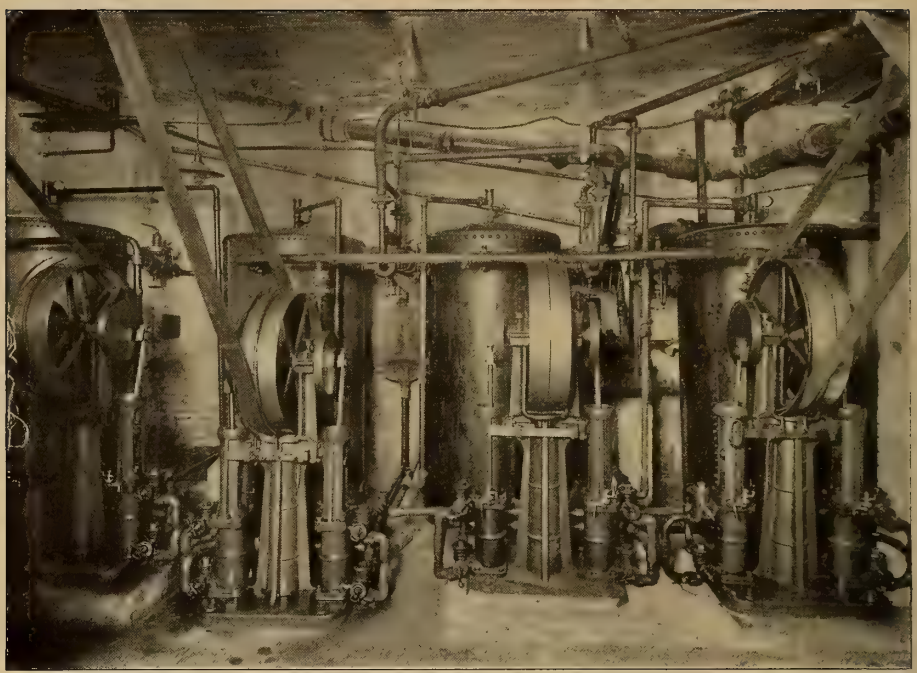
A very large variety of mantles are now upon the market, and most of these are of uniformly good quality. Mantles for burners of the "inverted" type are now being extensively introduced. The light given by an inverted burner with a good mantle is the most economical source of light known at the present day. The light is exceedingly steady and in general appearance resembles the Nernst electric lamp. For outlying villages where gas is not available, incandescent petroleum and spirit burners are being introduced. A number of patents have recently been taken out whereby an ordinary lamp burner is converted into one of the Bunsen type and adopted for use with the incandescent mantle. There are, however, many difficulties to be overcome, such as the imperfect vaporization of the petroleum or spirit and the blackening or smoking of the mantle. There should be a large de-

SORTING AND SEWING THE MANTLES

MANTLES ARRANGED READY FOR BURNING OFF

BURNING OFF THE MANTLES

PACKING MANTLES OF THE INVERTED VARIETY INTO CASES



COMPRESSORS FOR FURNISHING THE AIR USED IN BURNING OFF THE MANTLES

mand for lamps of this type, when they have been sufficiently improved to overcome these difficulties. They will form the best substitute for gas where the latter is not available. Nevertheless prices of alcohol and petroleum remaining as they are, gas is far more economical and convenient.

The chief drawback to the incandescent mantle is its tendency to break. The fragility of the mantle has almost become proverbial. We have every reason to hope, however, that this drawback will soon be partially eliminated if not entirely removed. A German firm, the Cerofirm Gesellschaft, of Berlin, is now manufacturing mantles in which the textile basis is neither cotton nor ramie but artificial silk. The artificial silk is made from cellulose by the copper process, but very little is known concerning the method employed in impregnating the fabric with the thorium and cerium nitrate. Hydrogen peroxide is to be employed for rendering the earths insoluble in the artificial fibres. There is no doubt whatever concerning the superiority of the mantle over previous productions as regards stability. The author had occasion to test one of the "Cerofirm" mantles to see if it bore out the statements made in its favour. After burning off the film it was possible to take it in the hand and bend it double without injuring it. An ordinary mantle tested under the same circumstances did not stand this treatment, but broke into pieces. In appearance these mantles are finer in texture, due to the essential difference between the nature of the fibre of artificial silk and that of ramie. The price is yet rather high, 1 shilling each in Germany. Nevertheless there seems to be a future for artificial silk as applied to incandescent mantles. A staple incandescent mantle would be an excellent weapon with which to compete against the increased efficiency of incandescent electric lamps using the various improved filaments.

INDUSTRIAL LEGISLATION AND ITS COST

By T. Good

At the present time, when legislation intended to regulate industrial operations of nearly every kind is unusually active, both in Great Britain and in the United States, it is desirable to examine in a calm and judicial manner the effect of the application of the legislative panacea to industrial ills.

Mr. Good speaks for Britain only, thus basing his views upon his own entirely adequate experience, but many of the points he makes apply equally well to America. He shows, especially in connection with the mining industries, that the improvements which have been made during the past half-century have been effected far more by the development and application of scientific methods of working than by any legislative enactments intended for the amelioration of the condition of the operatives, and in general he makes the argument that the benefits secured by legislation of this sort cost far more than they are worth, and that other means are far more effective.—The Editor.

A SUBJECT of much interest to those engaged in British industrial enterprise is that of legislative interference in labour affairs, especially in the present conditions of political activity, for what we may term the industrial legislation movement is very pronounced just now. With a new and comprehensive Workmen's Compensation Act to become operative on July 1, with a Royal Commission dealing with the problem of safety in mines, with Departmental committees dealing with industrial diseases, dangers attendant on building operations, and miners' hours of labour—all presaging further legislation of a restrictive character—the time is opportune to review some of the effects of past legislation carried in the interests of our workers. We may also offer a forecast of the cost and results of the new measures enacted, or projected, for while we rejoice in all that is accomplished towards the humanization of industry—in all that is done to protect labour and succour the victims of toil—we cannot fail to take cognizance of the increased cost of production, and of the consequent commercial handicap involved in the State regulation of labour conditions.

In reference to the new Workmen's Compensation Act it is interesting to recall a few circumstances connected with the working of former acts which have placed liability upon the employer. When the Workmen's Compensation Bill of 1897 was being pushed through Parliament the statesman credited with chief responsibility in the matter assured representatives of the textile trades that if the insurance companies were unwilling to cover the risks involved at premium rates of about 1s. 6d. per £100 of wages paid the employers' associations would do well to arrange the matter themselves. That was regarded as an authoritative estimate, based upon expert governmental advice, and the insurance companies agreed, at first, to

accept premium rates averging about 1s. 6d. per cent. in the case of textile operatives. But the insurance people lost money at those rates, and so much greater proved the actual cost of meeting claims than the original estimate that by 1905 the premium rates had reached an average of just about 6s. per £100 of wages paid in textile manufacturing.

In the case of the railways, one of the industries covered by the Workmen's Compensation Act (1897), the Board of Trade returns as to the numbers employed and wages paid and cost of compensation show that, for each £100 paid in wages 10s. have been paid in workmen's compensation.

Concerning the iron, steel, engineering and shipbuilding trades we have no complete records as to the average amount paid, per capita or per cent., in respect of accident insurance or compensation; but we have ample facts available for the purpose of a rough estimate, and may with advantage quote the experience of the Iron Trade Employers' Insurance Association. This association was formed shortly after the passing of the Workmen's Compensation Bill of 1897. Its management expenses have been low, and as it does not exist for the purpose of making profits practically the whole of its income, less expenses, goes in meeting claims. Indeed, during the last financial year, ending June 30, it paid out in claims and incidental costs £121,422, while its income reached only £118,640. Its management expenses for the year stood at 9.5 per cent. of income. The point of interest, however, is in the continually growing cost of meeting claims. Five years ago the premium rates of this association for engineers and shipbuilders averaged 7s. 9d. per £100 of wages. Last year they reached an average of 13s. 11d., and yet there was a deficit. The current average is 14s. 2d. But this is not all. This increasing cost has taken place in spite of vigorous efforts to check the tendency, not only by stiffening premiums but by refusing to renew the policies of firms with very bad accident records, and by other means.

With the bad accident record firms excluded from this particular association, with the association not seeking to make profits, and with premium rates averaging 13s. 11d. per cent. failing to meet cost of claims and expenses in connection with those favoured firms which remain members of this association, it becomes evident that the Workmen's Compensation burden, spread over the whole iron and steel industry, must average very much more than 13s. 11d. per cent., and must approach, if it does not reach, £1 per £100 of wages paid. Indeed, we know of iron compnies—not exceptional firms, either—who now pay considerably more than £1 per £100 of wages in compensation to workmen, or their dependents. This, be it noted, is under the old Workmen's Compensation Act.

Now we are told—and no one who has carefully considered the new act and is closely acquainted with industrial affairs will dispute that the cost of meeting claims will be at least doubled, per capita, by the more stringent and comprehensive provisions of the new act which comes into force on July 1, 1907. The prospect, then, is that the textile trades will be burdened to the extent of about 12s. per cent. on the average, and that the iron trades, which, of course, are much more dangerous, will be taxed to the tune of about £2 per cent. It may be that in the first year or two the cost will not be quite so high, but as time goes on, and the workpeople learn to take full advantage of the law, the burden may increase, and reach our estimate, unless preventive measures are adopted. Indeed, some of the insurance companies have already decided to impose premium rates upon the textile industries which will average, from the beginning, quite

15s. per cent., according to *The Yorkshire Post.* Of course, if the insurance companies seek to charge unreasonable rates the textile employers of Yorkshire and Lancashire may follow the example of some of the engineering employers, and conduct the business themselves. But it is a somewhat risky affair. The cost under the new act may increase progressively as under the old one. However, we do not think that in any case the ultimate cost can average less than 12s. per cent. in the textile industries. We put the minimum at that figure. Now, if that is to represent the cost in textiles, what is likely to be the burden on industries more dangerous? We have already estimated that it will reach £2 per cent. in the iron trades. Let us see what official figures indicate.

In proportion to numbers employed, according to deaths from industrial accidents recorded in the Board of Trade *Labour Gazette,* over a period of five years, 1901-5, we find that non-textile factories and workshops—those, at any rate, covered by the Non-Textile Factories and Workshops Act—are on the average three times as dangerous as textile factories; that the railway service is eleven times as dangerous; that quarrying is nearly fourteen times as dangerous; that mining is sixteen times as dangerous, and that seafaring is eighty times as dangerous as textile working. Here are the average annual accident death rates over the five years, 1901-5, taken from the *Labour Gazette,* April, 1906:—

Textile factory operatives, 0.72 per 10,000 employed; non-textile factory operatives, 2.23 per 10,000 employed; railway servants, 8.01 per 10,000 employed; quarrymen, 10.73 per 10,000 employed; miners, 12.88 per 10,000 employed; seamen, 58.06 10,000 employed; mean annual rate for all occupations reported, 6.56 per 10,000 employed.

NOTE.—Of non-textile occupations those connected with iron and steel are undoubtedly the most dangerous.

This means that bulking all the above occupations together, mining, manufacturing, railway and seafaring work, and all these industries are included within the scope of the new act, they are on the average nine times as dangerous (in point of fatal accidents) as textile working alone, so that if the new act is going to impose a burden of 12s. per cent. on the textile trades, the average burden on British industry in general may possibly work out at £5 8s. per £100 of wages paid; in other words, this Workmen's Compensation tax may possibly reach somewhere about £37,800,000 a year, calculating on an annual wages bill of £700,000,000. Of course, it is obvious that the ratio of non-fatal accidents to fatal ones is not so high in the mining and transport as in the manufacturing trades, and on that count our estimate might be modified; but, on the other hand, we must not forget that the cost of meeting claims under the old act has proved far greater than was ever anticipated, even by the experts.

It must not be inferred, however, that we assume, or that anyone with intimate knowledge of industrial affairs assumes, that the whole weight of this new burden will fall upon capital. Much of the weight will inevitably fall upon the very labour which is commonly supposed to gain everything and lose nothing by industrial legislation. This new imposition, on top of increasing local rates and high imperial taxation, will stimulate employers to effect further economies in their work. That such economies will be effected very largely at the expense of labour no one can doubt. Not only will employers be more than ever reluctant to engage elderly and delicate men, but the young and strong ones will be further speeded up. Our purpose is not to complain, but we would remind those who are forcing the pace of the industrial legislation movement that it is possible, under existing conditions, through excessive zeal and misdirected efforts, not merely to

harass capital, but to inflict hardships upon the labour they seek to benefit. And we contend that there are means of solving some of these labour problems other than legislative; but that question is outside the scope of the present article.

In our first paragraph we alluded to the question of miners' hours, and in the present circumstances no apology is needed for dealing at some length with mining legislation, for coal is the daily bread of industry—especially of the iron and steel trades—and anything that adds to the cost of coal mining is of vital national concern. What applies to coal applies, of course, to iron ore and other minerals to a certain extent, but for sake of brevity we name coal only. In coal mining legislation, as in other things, there is the human as well as the financial element. We shall deal briefly with both in view of certain projected legislative measures.

During the first half of the nineteenth century the miner's lot was probably worse than that of any other worker in Great Britain. Hard labour, long hours, and low wages; primitive appliances, inadequate ventilation, and bad drainage; infinite toil, danger and hardship were the predominating conditions of the miner's life. It is little wonder, therefore, that during the era of industrial legislation which started some fifty or sixty years ago, and has lasted down to the present time with still no show of slackening, miners' questions have been the most prominent of the labour problems dealt with by Parliament; for Parliament has, indeed, done more on behalf of the underground worker than for any other. Mining work has been rendered almost as safe as human laws can make it according to present knowledge. But there is one cardinal fact overlooked which it would be much better for all concerned frankly to recognize, and that is that much of the progress effected—much of the general improvement brought about, not only in increasing the safety of miners' work, but in benefiting workers in other industries—is not due, as is too commonly assumed, to legislative interference at all, but to the spread of knowledge, the growth of science, and the natural development of humanitarian ideas—to voluntary effort quite as much as to compulsory regulation. At the same time, no one can deny the need for, or the benefits of, some of this legislation.

The first bill dealing with mining labour in England was passed in 1842. This was "An act to prohibit the working of women and girls in mines," etc., etc. Prior to that women, in almost a nude condition, worked in the pits, harnessed like horses, drawing "corves" of coal from the workings to the shafts. Young children were also taken into the mines in those days. This Act of 1842, however, in addition to emancipating all women and girls from underground work, provided, among other things, that mine inspectors be appointed; that no boy under ten years of age be employed below ground; that winding engines, when winding men, should not be controlled by persons under 15 years of age; and that wages should not be paid in a public house.

In 1855, and again in 1860, amendments acts were passed—one "to amend the law for the inspection," and the other "to amend the law for the inspection and regulation" of mines. This latter act, besides extending the law to ironstone mines, provided that no boy under 12 years of age should be employed in a mine, unless he could read and write, or was permitted to attend school on two days a week for three hours; that engines, when winding men, should not be in charge of persons under 18 years of age; and that no land agent or colliery manager could be a mines inspector.

The Act of 1860 also provided for the fencing, lining and casing of shafts, for the ventilation of fencing of places likely to contain gas, for

proper drainage, for overhead covers on cages, for flanges on winding drums to prevent slipping, and other such safeguards, besides for notice of accidents and the abandonment of mines to be given to the inspectors, for wages to be paid in money only, and for miners to appoint their own checkweighman.

Two years later, in 1862, as the outcome of a terrible accident at the Hartley colliery on Jan. 15 of that year, on which occasion 202 lives were lost, another act was passed for the provision of duplicate shafts at all new pits, and providing that within three years all mines have not fewer than two outlets or shafts.

Next came the Coal Mines Act of 1872. The principal clauses of this act prohibited the employment of any boy under 12 years of age below ground; regulated the employment of boys, girls and women above ground, provided that wages be paid for actual weight of mineral gotten; that all mines be under control of certificated managers, and for the imprisonment penalty to be imposed upon owner, agent or manager for offences "reasonably calculated to endanger the safety of persons employed in or about the mine."

Then, after the passing of one or two acts of less importance, came the Mines Act of 1887—"An act to consolidate and amend" previous acts. This act became operative on Jan. 1, 1888. It repealed all former acts, and stands to-day, with slight amendments enacted in 1894 and in 1896, as our established law on mining labour. This act not only provides for nearly all the rules, regulations and safeguards contained in former acts, but makes many of them more stringent, besides adding a few new reforms in the interests of safety. For instance, the age of winding enginemen is brought up to twenty-two years; provision is made for more adequate timbering, draining and ventilating, for efficient lamps and the proper use of explosives, for ambulance appliances, such as stretchers, splints and bandages, for special inspection in the interests of workmen, for all coal getters to have not less than two years' previous experience at the face of the workings, for barometers and thermometers to be fixed at suitable places, for up-to-date signaling arrangements, etc., etc.

Now, what have been the most notable effects of all this industrial legislation? Whilst not denying the actual and beneficient effects of much of this legislation we still affirm that much of the progress effected has been mainly, if not entirely, due to causes other than legislative. The moral, social and educational conditions of our miners have been materially—have been, in fact, enormously—improved; and this improvement in the individual, this improvement in humanity due to the influences of a progressive civilization, is reflected, not only in improved technical knowledge, but in increased thought and care; and increased knowledge and caution bring a huge increase in safety. Partly through legislation, but chiefly, we believe, through improved knowledge, there has been a large measure of progress in lessening personal risk and injury during the last fifty years. During the last ten years the average annual number of workers killed by accidents in British coal mining has not represented more than one in every 770 employed in or about the mines. During the ten years ending 1855, the percentage of mine workers killed to those employed was equal to one in every 250. This is to say that the miner's work is now three times more safe than it was half a century ago.

It is worth while mentioning here that in fatal accidents in coal mining England has a lighter percentage than Germany, and a much lighter one than America, although we do not stand quite so favourably as France and Belgium. Between 1895 and 1904 the percentage of miners killed in the United States rose from

2.67 to 3.38 per 1000 employed; whilst in Great Britain the percentage declined from 1.49 to 1.35 per 1000. It is still slightly worse than France and Belgium in the matter of accidents calculated on the basis of numbers employed, and Britain stands better than any important country in proportion to tonnage raised.

At this point, however, for the present, we leave the human and turn to the business side of the question. Fifty years ago we find—estimating from the returns for the year 1855—the annual output of coal per person employed in and about our coal mines to have averaged 265 tons. In those days mining appliances were of necessity primitive in character, and a large proportion of the workers were women and young children. All that is now changed; women and children have been banished—rightly banished—from below ground; few are employed above ground; all workers in the mine are men or youths in their teens; wages are quite 50 per cent. higher now than then; comfort and safety in working are alike greater; appliances, equipment and methods are incomparably better; and yet the output of coal in recent years, per person employed, has only been at the rate of 275 tons a year. It was only ten tons per worker more in 1905 than in 1855.

We are prepared to admit, of course, that generally somewhat thinner seams of coal are worked now than fifty years ago; but against that we place the infinitely superior appliances of to-day, the improved health and physique of the workers, the increased comfort, safety and healthfulness of mining—fifty years of industrial legislation involving a huge increase in cost of plant, equipment and appliances, and, concurrently, in cost of production. The fact remains that, chiefly through legislation, partly through trade unionism, and partly through other influences, although health and general working conditions have been vastly improved, and at great cost individual effort has been lessened.

The cost of getting coal—this important material of industry—in labour alone, apart from the cost of more modern plant and appliances, has gone up during the last fifty years from 2s. 6d. to 4s. 6d. per ton; whilst legislation must have added at least 2s. per ton—partly in labour and partly in appliances. Two shillings per ton of coal raised means £24,000,000 a year.

Mr. Hewlett, in his evidence before the Royal Commission on Trade Depression, said that the Mines Act of 1872 alone had added 8d. per ton to cost of coal production. The amendments contained in the Act of 1887 added not less than another 3d. per ton; and between 1872 and 1887 there was other legislation. One eminent colliery proprietor, the Earl of Granville, in a speech in the House of Lords, put the increased cost of production due to legislative enactments within a period of sixteen years, including the Acts of 1872 and 1887, at from 1s. to 2s. per ton, according to the different circumstances of the various mines; whilst the late Mr. C. M. Percy, of Wigan, an independent authority on mining matters—in fact, an advocate of industrial legislation—admitted that the increased cost of coal getting imposed by those Acts of 1872-1887 was not less than 1s. per ton on the average. We are justified, therefore, in our estimate that state regulation within a period of about half a century has added 2s. per ton to the cost of coal getting, for not only have we had mines acts and mines amendment acts, but also employers' liability acts and workmen's compensation acts following one another in rapid and fairly regular succession, invariably adding to cost of production. Then, again, sanitary, educational, parochial and other matters have also increased industry's burdens out of all proportion to the resultant benefits. Within fifteen years local rates have gone up from

an average of 3s. 8½d. to 5s. in the pound sterling.

With still more legislation of a restrictive character now being energetically pushed forward we earnestly commend these figures and calculations to the consideration of those whose interests are bound up with the mining and manufacturing industries of this country. With industrial legislation now carried so far that it adds something like £24,000,000 a year to the cost of our coal, and will shortly add something like £37,000,000 a year on our industries in shape of workmen's compensation, we ask is it not time for a new policy to be adopted in our industrial affairs? Is it not time that capital and labour settled their differences without the vexation and cost of State interference?—on lines previously laid down in this magazine? *

*Cassier's Magazine, September, 1906.

AERIAL CABLE CONSTRUCTION FOR TELEPHONE EXCHANGES

By C. W. Burkett

The following discussion of the construction of telephone cables contains the substance of an address delivered by the author before the seminary on electrical installations at the University of Wisconsin, and has been revised and illustrated for publication here. Mr. Burkett is especially competent to write of the practical and technical details of this department of electrical work, being Chief Engineer of the Wisconsin Telephone Company, and an Associate Member of the American Institute of Electrical Engineers.—The Editor.

ONE of the problems met with by the telephone engineer of to-day, is that of providing a pair of wires from a predetermined centre to each telephone. To accomplish this requires, in many instances, the extensive use of aerial cable, and it is the purpose of this paper to outline, in a general way, the present-day practice in aerial cable construction for telephone exchanges. The subject is one of very great importance in telephone work to-day, as this extensive use of aerial cable requires considerable capital.

With the invention of the telegraph came the necessity for continuous metallic conductors between points often many miles apart, and, strange to relate, the first several miles of telegraph wire from Baltimore was laid underground in lead pipes and placed in a plowed furrow. But the wires so laid were not operative for reasons at that time not known, and one of Morse's contemporaries made the suggestion that the wires be "hung up in the air."

Following the suggestion to "hang up the wires," a small portion of this first telegraph line was placed on poles with cattle horns for insulators and so successful was this scheme that the remainder of the whole line from Baltimore to Washington was built in this way.

Tracing the development of the construction of electrical conductors, we find that this first method has been improved only in construction details.

The first public exhibition of the telephone was made at the Centennial Exposition at Philadelphia in 1876. Subsequent development in the demand for telephone service required an enormous wire plant construction. This unusual demand created new problems of great moment and complexity.

At first, telephone wires were placed in the way that telegraph wires were placed, but the number of wires needed increased so rapidly that the placing of wires in cable form became imperative if the business was to develop and the use of the telephone was to become universal.

Those old-time telephone plants were called "open-wire plants" and much of this construction is to be seen throughout the United States to-day. It is, however, disappearing quite rapidly and in a few years the open-wire telephone exchange will be an exception.

It is believed that the first aerial cable for telephone use was installed at Philadelphia in 1881. About this time experiments were being made at Providence, Brooklyn, and Boston. These first telephone cables were

made of parallel rubber-covered wires and the electrostatic capacity was so great that with a third of a mile of such cable inserted in a telephone line subscribers complained that they could barely hear.

It was found also that the induction between the parallel wires of the cable was so great that serious cross-talk resulted. This induction was overcome by placing the wires in twisted pairs, and later the electrostatic capacity was reduced and transmission correspondingly improved by insulating the wires with paper. It was found later, however, that the improvement was due, not to the paper, but to the occluded air among the twisted paper.

Improvements have been made from time to time in the design and manufacture of telephone cable, until to-day, as good telephone transmission can be secured without special devices (such as loading coils and repeaters) over ten (10) miles of standard No. 19 B. & S. gauge cable as over 285 miles of No. 8 B. W. G. copper aerial circuit. At present the theoretical limiting distance of standard telephonic transmission over a No. 19 B. & S. gauge circuit in cable without special devices is, approximately, 29 miles.

Some of the reasons for constructing telephone exchange wire plants on what is known as the "all-cable" basis, are as follows:—

1. Because wires in cables are more economical to maintain than those in the open.

2. Because the larger number of wires necessary in telephone work makes all open-wire plants physically impossible.

3. Because of the unsightliness of structures carrying great masses of open wires.

4. Because of the greater surety of uninterrupted service with wires in cables than with wires in the open.

5. Because the first cost and fixed charges of an all-cable plant are less than that of the open or partly open-wire plant.

An all-cable plant must be designed so that pairs of wires are available in cable from the central station to within a few hundred feet of any subscriber,—present or prospective. In the early days of telephone construction, there was no thought of a comprehensive or systematic aerial construction. Cable was expensive and the rule was to get along with as little as possible. But the present-day remarkable demand for telephone service has made carefully engineered plans for all parts of the telephone plant a necessity.

I will outline, briefly, a routine for the preparation of plans for an all-cable system of distribution for a given exchange area with a center previously determined.

INITIAL CONSTRUCTION, ECONOMICAL PERIOD.

The economical period for which the initial construction should provide must be determined. The length of this period varies inversely with the price of cable being derived from the first cost and fixed charges.

With the present cost of construction it is economical, in general, to install aerial cable to care for all business that may be secured within five years. This economical period will probably be increased in the future rather than decreased.

FUTURE POPULATION.

An estimate of the population of the exchange area at the end of the economical period must be made, as the number of telephones to be provided for will depend upon the population. This is arrived at according to the method described in the United States Census Bulletin No. 135, of Jan. 30, 1902.

AMOUNT OF BUSINESS TO BE PROVIDED FOR.

An estimate of the number of subscribers to be served in the exchange area within the given period must be made. To do this with any degree of accuracy is one of the most difficult problems at present in telephone en-

A TYPICAL OPEN-WIRE TELEPHONE CONSTRUCTION. THE ALL-CABLE CONSTRUCTION AVOIDS SUCH STRUCTURES

gineering as there is a considerable diversity of opinion concerning the amount of telephone development to be expected in different sections.

At present at 15 or 20 per cent. development, depending upon the community is considered saturation. That is, in an exchange area, 15 or 20 per cent. of the population in five years will be the number of telephones for which provision must be made.

A study of the present development is most interesting. The development in the New England States of America is 3.48 per cent. Of other countries, Sweden has a ratio of 2.11 telephones per 100 inhabitants, and Great Britain has a ratio of 0.86 telephones per 100 inhabitants.

In the larger cities of the United States there is more uniform development. It is peculiar, however, that the greatest development in the United States has been on the Pacific Coast. This has been attributed to the fact that the population is "new" and has the characteristic of all new places, *i. e.*, of making use of every new idea. The city of San Francisco had a ratio, Jan. 1, 1905, of 12.5 telephones per 100 population, while Chicago has a 4.7 per cent. development, and New York a 4.6 per cent. development.

In the State of Wisconsin, Milwaukee has a 5.6 per cent. development, while many of the smaller towns have from 7 to 12 per cent. development.

Some telephone engineers believe that the number of telephones that may be required in a community is limited only by the number of families in that community. Estimating that the average family consists of five, and that the population of the United States is eighty million, sixteen million instead of four million telephones (which is the estimated total number in use by all companies) would be required to give each family telephone service. These facts are mentioned to give an idea of the magnitude of the problem which confronts the telephone engineers of today.

DISTRIBUTION OF ESTIMATED NUMBER OF TELEPHONES.

The distribution of the total estimated number of telephones predicted for the end of the economical period must be made by blocks or by other small areas. This is accomplished by making a careful survey of the exchange area to classify telephonically the business houses, residences and unimproved real estate. The finished map showing the result of this survey is called a "character map."

This map shows the character of buildings and of unoccupied land in the exchange area, and, briefly, by legend, office buildings, wholesale business districts, retail districts, manufacturing districts, residence districts, divided into first, second, third and fourth class, undeveloped land capable of future development and undeveloped land incapable of future development.

The classification of residences is relative, and a first-class residence in one city might be rated second class in another city. The division is made entirely on the basis of the possibility of demand for telephone service. A first-class residence is defined as one, which, under all ordinary circumstances should be provided with telephone service, while second-class residences are those in which a telephone would be expected in one-half the residences, and third-class residences would have a telephone service in every third or fourth house. Fourth-class residences would be those which would require telephone service only in rare cases.

Occasionally exception must be taken to these rules, for example, a railroad man living in a poor residence, but having a special need for telephone service. This condition exists in the Northern part of La Crosse, Wis., where there is a telephone in nearly every residence, none of which could be classed as first- or second-class La Crosse residences.

LOCATION OF CABLE ROUTES.

Cable routes are determined largely by the topography of the exchange area and other local features. The routes should be as short as possible so that the subscribers' loop will contain a minimum amount of conductor, and in city work leads should preferably be placed in alleys.

Where alleys do not exist, privileges of the use of rear property lines can usually be secured.

THE SIZE, KIND AND LOCATION OF CABLE TERMINALS.

The size of the cable terminal depends on the number of telephones to be served from the same, as determined by the development study. The averaged sized terminal used today is 15 pair, but both 10 and 25-pair terminals are used extensively.

Terminals may be either protected or unprotected. Where the lines served from the terminal are especially liable to become crossed with high potential and lighting wires, or are exposed to damage by lightning, the protected terminal is used. This protected terminal consists of a fuse, and for very long lines is supplemented by open-space cut-outs, made of carbon plates, separated with mica of .011 inch thickness. The fuse is of tubular form of 5 amperes capacity, and is rated to blow on 8.5 amperes in less than 5 minutes.

The unprotected terminal is so ar-

ranged that the open wires may be directly connected to the cable wires without any protective apparatus whatever. This type of terminal is used where the open wires are not exposed to danger from lightning or contact with foreign electrical conductors.

SIZE AND KIND OF CABLE.

The number of pairs of wires to be placed in a cable depends upon the number of telephones to be served by the cable. Unlike power and lighting cables, no overload can be cared for in telephone cables. A cable that will care for 400 telephones will not care for either one or twenty more telephones. This, together with the fact that the largest sized cables in place ready for service may cost as much as $4,000 per mile makes careful engineering a necessity. From the economical standpoint, a cable too small must be replaced before it has earned the charges against it, while a cable too large represents investment upon which no return can be secured. At present the standard sizes of exchange aerial cable are 15, 25, 50, 100, 200, 300 and 400 pairs.

To serve five subscribers, a 15-pair cable is ordinarily specified. To serve 45 subscribers, a 100-pair cable would be specified, while 100-pair cable would also be specified to serve 60 subscribers. For 200 subscribers, a 400-pair cable would be installed.

The size of the conductors to be used in telephone cable is determined by the length of the sub-station loops to be carried through it.

Loops in single office exchanges must not have over 500 ohms resistance if No. 22 B. & S. gauge cable is used.

In multi-office exchanges, the resistance must not be over 350 ohms in No. 22 B. & S. gauge cable for subscribers' loops.

Two types of cable are used as concerns electrostatic capacity, and in this respect cable is known as being either "high" or "low" capacity.

Under certain severe transmission requirements, the low-capacity cable must be used, although it is more expensive than the high-capacity cable. In No. 19 B. & S. gauge, low-capacity paper cable, the maximum mutual electrostatic capacity measured between a wire of a pair (the remainder of the conductors being connected to the sheath), must not exceed 0.060 microfarads per mile of cable, while high capacity No. 19 B. & S. gauge cable must not exceed 0.087 microfarads per mile of cable.

No. 22 B. & S. gauge cable is manufactured with a maximum electrostatic capacity of 0.078 microfarads per mile.

The insulation of all wire in cable must be not less than 500 megohms per mile of cable, each wire being measured against all the rest and the sheath with an electromotive force of from 500 to 550 volts.

All cable sheath must contain not less than 3 per cent. of tin, with a thickness of from 1-12 (.93) inch for the smallest cables to $\frac{1}{8}$ (.125) inch for the largest cables.

THE DISTRIBUTION OF CABLE CONDUCTORS.

To provide a pair of wires from the central office to each terminal for each prospective subscriber would be a most expensive proceeding, and in order to accomplish this end without actually installing the wires, multiple distribution of cable conductors has been devised. This multiple distribution of conductors is arranged, as the term implies, so that the same pair of wires is multiplied to two or more different terminals, at any of which it is available for use if not in use at some other terminal.

This arrangement provides a safeguard to cover small errors in estimating the number of future telephones. It also proves valuable in systems where party lines are used, as by this method stations may be connected to the same line at different terminals.

AN OBSOLETE METHOD OF DISTRIBUTING TELEPHONE WIRES FROM UNDERGROUND CABLES

Many of these multiple distribution schemes have been developed, all based on the elemental idea of making one pair of wires available at quite a number of different points.

A 400-pair cable may have as many as 100 15-pair terminals. This means that every pair of wires will be available on an average at 3.75 different points.

The earliest multiple system of cable conductors, and one which is used to considerable extent at present, is called the "direct lap" system. Such a distribution would begin in this way:—

Terminal No. 1, pairs 1-20.
Terminal No. 2, pairs 11-30.
Terminal No. 3, pairs 21-40.

Another system is to have a certain group of conductors appear at all terminals.

These multiple distribution schemes become more complicated and involved when terminals of different sizes are used, and where the ultimate number of telephones to be provided for becomes more and more uncertain. Some of the later systems devised are too complicated to be described in this paper.

POLE PLAN.

The plans for the cable plant are now completed, with the exception of determining the location of poles for supporting the cable. For the main leads, poles with "6-inch" tops are used. A 30-foot pole of this class has a circumference of not less than 22 inches at the top and 36 inches at 6 inches from the butt. Poles of other lengths should have correspondingly proportional dimensions.

Poles with "5-inch" tops should be used in alleys and on property lines where cables not heavier than 100-pair No. 22 gauge are to be supported. A 30-foot pole of this class has a circumference of not less than $18\frac{3}{4}$ inches at the top and 33 inches 6 inches from the butt.

The height of poles must be determined for each piece of work. In general, they should be as short as is consistent with municipal regulations or with such obstacles as may be met.

The practice at this time is to place all cables and telephone wires, where possible, below the lighting and power wires because the telephone wires are usually greater in number than the lighting and power wires and break under sleet and wind before the lighting and power wires do.

Care must be taken that anchors and stubs are of the right sizes and are properly placed. With the larger sized cables, which may weigh from 6 to 8 pounds per foot, this is a vital matter, and one which must be determined for each piece of work.

Poles for cable work should be set to the following depths:—

25-foot pole, 5 feet in the ground.
30-foot pole, $5\frac{1}{2}$ feet in the ground.
35-foot pole, 6 feet in the ground.
40-foot pole, 6 feet in the ground.
45-foot pole, $6\frac{1}{2}$ feet in the ground.
50-foot pole, 7 feet in the ground.

In cable work it is necessary to step only poles on which terminals are placed.

CONSTRUCTION DETAILS.

The paper telephone cable is a delicate structure, which the slightest moisture will render unserviceable. For this reason great care must be taken to see that all construction details will insure against moisture entering the cable.

The cable is hung on messenger strand, fastened to poles or to cable cross-arms with suspension clamps. Three kinds of this strand are used according to the following rules where the spans are less than 150 feet.

For 50-pair No. 19 gauge cable or 100-pair No. 22 gauge cable and smaller, messenger strand having a minimum breaking weight of 6,000 pounds should be used. This strand is composed of seven No. 12 galvanized steel wires twisted together.

For 100-pair No. 19 gauge cable or 200-pair No. 22 gauge cable, messenger strand having a minimum break-

THE ALL-CABLE METHOD OF DISTRIBUTING WIRES DIRECTLY FROM CABLE ON SHORT POLES IN ALLEYS. A SATISFACTORY METHOD IN SUBURBAN DISTRICTS

A METHOD OF DISTRIBUTING WIRES ON WALLS DIRECTLY FROM UNDERGROUND

ing weight of 10,000 pounds should be used. This strand is composed of seven No. 13 B. W. G. galvanized steel wires twisted together.

All cable larger than this should be strung on messenger strand having a minimum breaking weight of 16,500 pounds. This messenger strand is composed of seven No. 11 B. W. G. galvanized steel wires twisted together.

Where more than two cables are to be placed on one pole, steel cable cross-arms having a capacity of six cables are ordinarily used.

The amount of sag in feet to be used in placing cable is as follows:—

Spans 100 feet or less, 2-foot sag.
Spans 115 feet, 2½-foot sag.
Spans 130 feet, 3-foot sag.
Spans 145 feet, 4-foot sag.

Where cable is liable to either electrical or mechanical injury from foreign conductors or from trees, it must be protected by substantial moulding. A boxing of wood is generally used, although metal tuning is used in some cases.

As a rule the marlin cable hanger is used for attaching cable to the messenger strand. The hook of this hanger is made of galvanized steel wire of not less than 0.144 inch in diameter (No. 9 B. W. G.), and must not open when subjected to a load of 100 pounds. The marlin or house line must stand a strain of 330 pounds without breaking when looped around a 1-inch rod. Different sized loops are used for the different sized cables.

Cable hangers are placed 15 inches apart on a 200-pair No. 22 gauge cables and on 100 pair No. 19 gauge cables and larger, and 20 inches apart on all smaller cables.

In special cases, such as at railway crossings, in the vicinity of chemical works and with certain atmospheric conditions, an all-metal cable hanger is used. All-metal cable hangers would be used universally if they could be manufactured as cheaply as the marlin hanger and devised so as not to hold the cable rigidly to the messenger strand.

It is considered good practice to bond aerial cable sheaths together and ground the same at frequent intervals.

Splices in cable must be made with great care. At each splice in a 400-pair cable, 800 wires must be joined together electrically and the joint insulated from every other wire.

The joint is made by removing the paper insulation from the ends of the wires and twisting the bared wires together. Solder is never used in paper cable, and, strange to say, open wires in splices made this way are rare.

The splices in the wire are insulated by enclosing them in small paper sleeves.

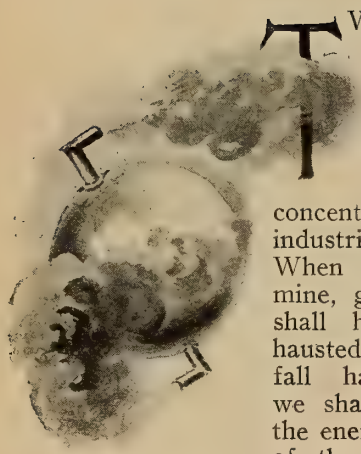
"Multiple" splices are more complicated than "straight" splices, especially where more than two branch cables lead from the same splice.

With a community "cabled" for a telephone to each family, one feels that Goethe must have had a premonition of such a condition when he wrote:—

"Truly the fabric of mental fleece,
Resembles a weaver's masterpiece,
Where a thousand threads one treadle throws,
Where fly the shuttles hither and thither,
Unseen the threads are knit together,
And an infinite combination grows."

THE STEAM TURBINE

By Charles Proteus Steinmetz



TWO only of Nature's stores of energy, the coal mine and the waterfall, are sufficiently concentrated to be of industrial importance. When the last coal mine, gas or oil well shall have been exhausted, the last waterfall harnessed, then we shall have to use the energy of the rays of the sun, and the force of the winds and tides. But at present the cost of collecting considerable amounts of power from wind or waves, sunlight or tides, is such as to make it impracticable, except in a very limited degree, such as in the pumping of water by wind power, etc.

Energy can exist in two forms, as potential energy or energy at rest, and as kinetic energy or energy of motion. For instance, in the discharge of a rifle, the chemical energy contained as potential energy in the powder is transferred to the bullet as kinetic energy or momentum.

A problem of mechanical engineering then is the transformation of Nature's stores of energy into the forms adapted for industrial uses, usually the mechanical energy of rotation. Two classes of prime movers or transformers of stored energy into mechanical rotation then exist: those using potential energy, and those using kinetic energy.

For instance, a reservoir of water at an elevation or heighth represents a store of energy. We can use this energy by letting the water fill the buckets of a large wheel, as sketched in Fig. 1, and the weight of water pressing down the right-hand side of the wheel makes the wheel turn. Here the water does the work by its weight or potential energy. As long as all the buckets on the down-going side are filled, the wheel will give the same torque, whether it moves slow or fast; but the faster it moves the more water it takes, and the more power it gives. That is the theoretical power of the hydraulic engine using potential energy, as the overshot waterwheel is proportional to the speed, and the theoretical efficiency independent of the speed. Hence, the speed has no direct effect on the efficiency as long as the speed of the wheel is low, compared with the speed of falling water.

The waterpower can also be used by letting the water run down through a pipe, and spout out of an opening or nozzle at the lower end of the pipe. Then the potential energy of the water, as represented by the elevation of the reservoir above the outlet of the nozzle, appears as kinetic energy in the velocity of the jet of water and can be used, as sketched in Fig. 2, by the jet of water striking the blades of a wheel and so setting it into rotation. Or, the nozzles from which the water spouts can be made movable, so that the water leaving the nozzle pushes it backwards by its recoil or reaction and so produces rotation, as sketched in Fig. 3. Such an engine, using the kinetic energy of the fluid, is called a turbine: an impulse or action turbine, if, as in Fig. 2, the motion is produced by the impulse of the stationary jet on a moving wheel; a re-

action turbine, if the motion is produced by the reaction or recoil of the movable nozzles, as in Fig. 3. This gives two forms of kinetic engines or turbines: the impulse turbine, and the reaction turbine. Numerous combinations of both can be devised, so-called combination turbines.

In the field of hydraulics, the tur-

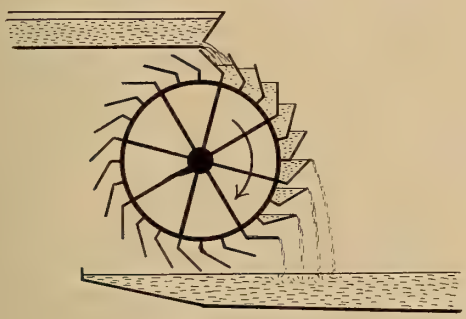


FIG. 1—OVERSHOT WATER WHEEL

bine has practically superseded the water-wheel, because the turbine is smaller, more powerful and gives higher speeds than the water-wheel,

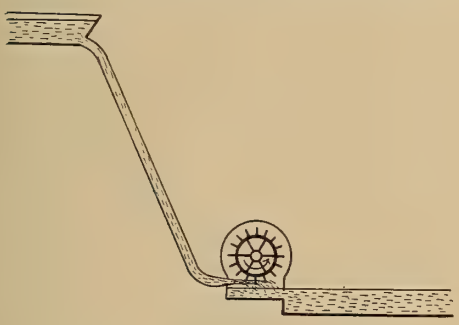


FIG. 2—IMPULSE WATER WHEEL

which is a very slow speed engine.

The energy of waterpower as well as of the coal mine is that of stored solar action. The energy of the sun evaporates the water of the oceans and the lower levels and so raises it as vapour to the clouds to be collected again as water on the higher levels and feed the creeks and rivers. In the coal mine we have prehistoric solar energy stored as chemical energy. By combustion this chemical energy is converted into heat, and the heat energy transferred to water and so used in the steam engine, or used directly in the gases of combustion in the gas engine. So far, the gas engine, while greatly improved in the last years, and of an efficiency superior to that of the steam engine, has not yet reached an industrial importance comparable with that of the steam engine.

With heat as source of power, two types of motors exist similar to the water-wheels: those using the potential energy of the working medium, as the steam, and those using its kinetic energy.

In the reciprocating steam engine, as sketched in Fig. 4, the steam, admitted to the cylinder on one side of

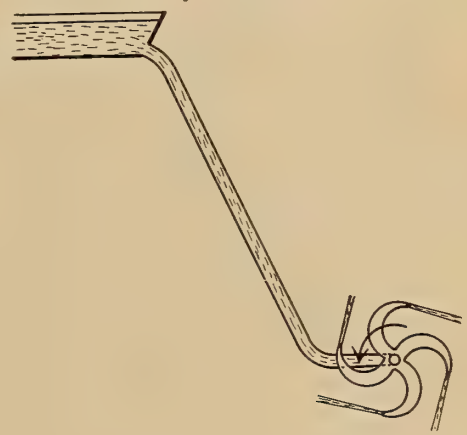


FIG. 3—REACTION WATER WHEEL

the piston, pushes the piston by its pressure, first during admission, then during expansion: at the end of the stroke the movement is reversed, and the steam, admitted on the other side of the piston, pushes it back, and this reciprocating motion is transformed into rotation by crank and fly-wheel. Here, it is the potential energy of the steam, as represented by its pressure and volume which does the work, and like all engines using potential energy, the speed has no direct effect on the efficiency, but every stroke of the piston, whether rapid or slow, when consuming the same amount of steam, gives theoretically the same amount of mechanical energy.

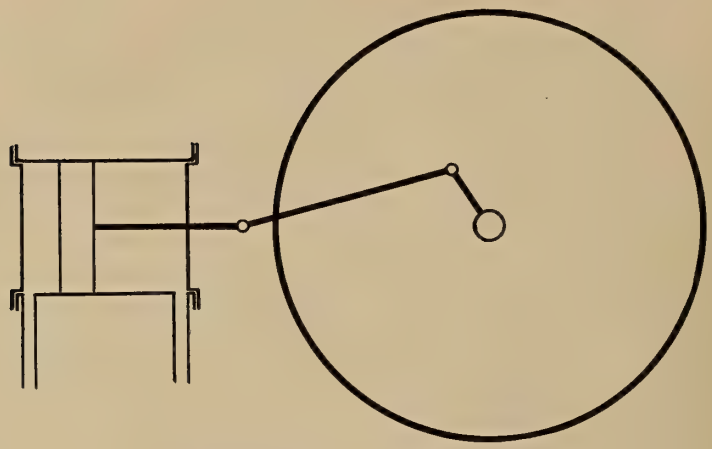


FIG. 4—DIAGRAM OF RECIPROCATING ENGINE

The turbine principle can also be applied to the thermal engine with steam or with the gases of combustion as the working fluid: the steam, escaping from a nozzle from higher to lower pressure, and so changing its potential energy of pressure into kinetic energy of motion is made to do work in an impulse turbine with stationary nozzles and revolving wheels, or in a reaction turbine with revolving nozzles, or in a combination of both types.

So far, the problem is the same as that of the hydraulic turbine, and indeed the turbine is the oldest type of steam engine proposed. Still, its development is recent and it is only in very recent years that the steam turbine has become an important industrial factor.

To understand the reasons we have to consider the velocities of water jets in hydraulics, and steam jets in steam turbines, in their relation to the peripheral speed of the turbine wheels.

If a jet of water or steam coming from a stationary nozzle N, Fig. 5, strikes the blades B of a moving wheel, the jet rebounds from the blades with the same relative velocity with which it strikes, if the blades are properly shaped so that the rebounding jet does not interfere with the impinging jet. If, therefore, v is the velocity of the jet coming from the nozzles, s the velocity of the blades or buckets B, the relative velocity with which the jet strikes the blade is $v - s$, and this also is the relative velocity of the rebound of the jet from the blade. That is, the jet in Fig. 5 leaves the blade at a velocity towards the left of $v - s$, and this also is the relative velocity of the rebound of the jet from the blade. That is, the jet in Fig. 5 leaves the blade at a velocity toward the left of $v - s$ relative to the blade, and since the blade moves with the velocity s towards the right, the absolute velocity of the rebound is $(v - s) - s = v - 2s$. In the impulse turbine the jet striking and rebounding from the moving blades of the wheel loses in velocity by twice the velocity of motion of the wheel blades. This loss of velocity, and, therefore, of energy of the jet, represents the energy which has been transferred to the moving wheel and gives the work done by the turbine wheel. It is a maximum, if all the velocity of the jet has been given off to the moving wheel, that is, if the residual velocity $t = v - 2s$ equals zero. This is the case if $s = \frac{v}{2}$. Hence, in an impulse turbine, the theoretical output and efficiency are

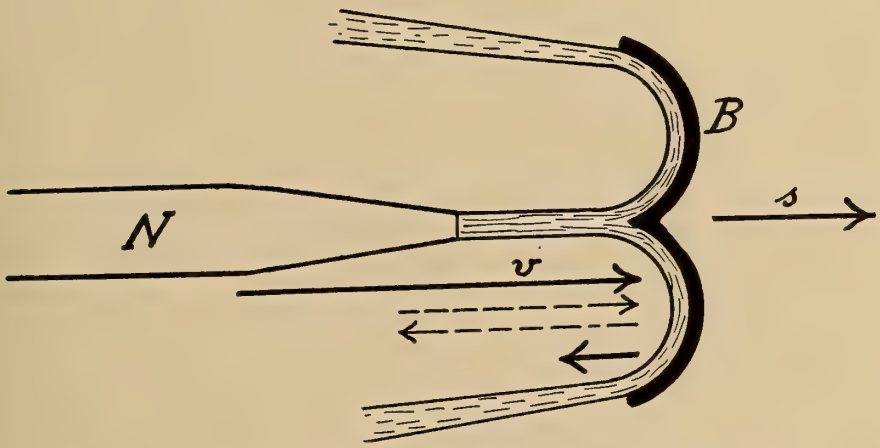


FIG. 5—JET AND IMPULSE BUCKET WHEEL

a maximum if the peripheral speed of the turbine wheel equals half the spouting velocity of the jet of water or steam.

In a reaction turbine, Fig. 6, if the spouting velocity of the jet issuing from the nozzle N is v, and the nozzles, that is, the turbine wheels, move backwards with the velocity of s, the absolute velocity of the jet, that is, the velocity left in the jet after passing from the turbine wheel, is $t = v - s$. Hence, in a reaction wheel, the jet loses a velocity equal to the wheel velocity by transfer of energy to the wheel and the theoretical output and efficiency are a maximum if all the velocity of the jet has been given off, that is, if $s = v$.

The most efficient peripheral speed of the reaction turbine, therefore, is a speed equal to the spouting velocity of the jet, while the most efficient peripheral speed of the impulse turbine is equal to only half the spouting velocity of the jet. With a combination turbine, the most efficient speed is between the two values, or more than half and less than the full spouting velocity of the jet.

The impulse turbine, with the same

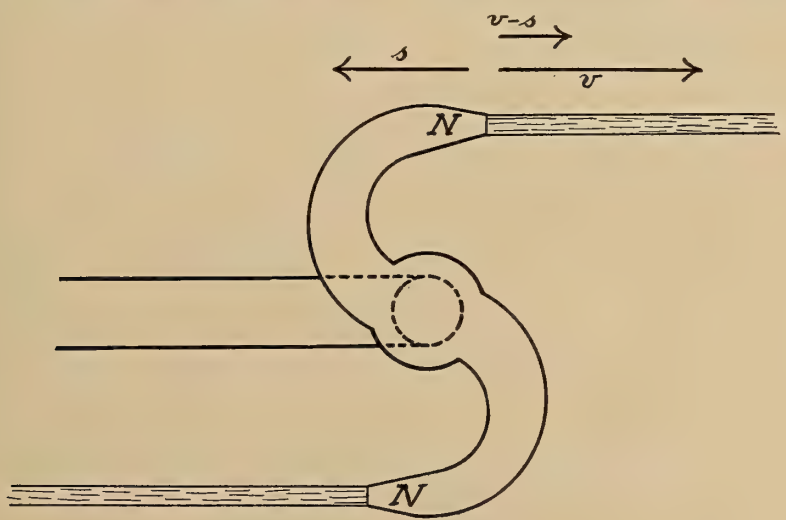


FIG. 6—DIAGRAM OF REACTION TURBINE

spouting velocity, that is, the same head of water, therefore requires a lower peripheral speed than the reaction turbine.

The spouting velocity v of the jet of water issuing from a nozzle depends upon the head of water h, that is, the difference between upper level and lower level or nozzle outflow, or upon the pressure p, since the pressure p is proportional to the head h, that is, it is the weight of water column of height h.

The potential energy of a weight w of water, with an available height h, is wh. This energy must be contained in the jet of water leaving the nozzles, as kinetic energy $\frac{1}{2}mv^2$. Hence, $wh = \frac{1}{2}mv^2$, and since the mass m equals the weight w divided by the acceleration of gravity, $g = 32$ feet: $m = \frac{w}{g}$, it is: $wh = \frac{1}{2}\frac{w}{g}v^2$, or, $v = \sqrt{2gh} = 8\sqrt{h}$ is the spouting velocity of the jet.

If W is the available energy of 1 pound of steam expanding from pressure p to pressure q, the energy of w pounds of steam is wW, that is, the available energy per pound of steam takes in the steam equations the same place as the height h in the equations of the water power, and the spouting velocity of a steam jet, therefore is:—

$$v = \sqrt{2gW} = 8\sqrt{W}.$$

The available energy per pound of steam W, depends upon the pressure of the admitted steam p, and the pressure of the expanded steam q, as the boiler pressure and the condenser pressure, and is:—

$$W = 426{,}000\ p^{.06}\left\{1-\left(\frac{q}{d}\right)^{.112}\right\}\begin{matrix}\text{ft.}\\ \text{lbs}\end{matrix}$$

Peripheral speeds of moving apparatus usually are between 3,600 and 7,200 feet per minute, or 60 to 120 feet per second. At speeds higher than this, centrifugal forces become serious and require special consideration, so that higher speeds are avoided where possible, and at lower speeds the size and thereby cost of the apparatus usually increases.

The most frequent heads of water powers h are from 20 to 100 feet. Lower heads, from 10 to 20 feet, it usually does not pay to develop. Heads from 100 to 200 feet are rare in the Eastern portion of the United States, while in the West, heads as high as 500 to 1,000 feet and even higher are found.

Herefrom follow the spouting velocities of the jet of water, and the desirable peripheral speeds of impulse and of reaction turbines, as follows:—

Head of Water, h.	Spouting Velocity, $v = 8\sqrt{h}$.	Peripheral Speed of	
		Impulse Turbine.	Reaction Turbine.
Feet.	Feet per Sec.	Feet per Sec.	Feet per Sec.
10 to 20	25 to 36	13 to 18	25 to 36
20 to 100	36 to 80	18 to 40	36 to 80
100 to 200	80 to 100	40 to 55	80 to 110
500 to 1000	180 to 250	90 to 125	180 to 250

As seen throughout the whole range of heads of water powers from 20 feet to 1,000 feet, the peripheral speed of economical operation of either a reaction turbine or an impulse turbine is within the range of mechanically desirable peripheral speeds of revolving apparatus. For low heads, the reaction turbine has the advantage, for high heads, the impulse turbine.

The water-wheel, however, which requires a peripheral speed, low, compared with the spouting velocity, is below the economical range of peripheral speeds.

In hydraulic engineering, therefore, the turbine holds the field undisputed.

An entirely different condition appears when we consider spouting velocities of steam.

Economical boiler pressures are from 140 to 180 pounds, or about 160 pounds above the atmosphere, that is, about 175 pounds absolute. The exhaust pressure into the atmosphere is the atmospheric pressure of about 15 pounds. Condenser pressures vary from 2 to 1 pound absolute, or,

as usually expressed, 26 to 28 inches vacuum. An approximate pressure range for a non-condensing steam engine, therefore, is from 175 to 15 pounds absolute, and for a condensing engine from 175 pounds to 1 pound absolute.

The available energy of expansion of 1 pound of steam, from 175 to 15 pounds, is given by the equation stated above, as:—

$W = 139{,}000$ foot-pounds.

This gives a spouting velocity of the steam jet $v = 8\sqrt{W} = 2{,}980$ feet, per second.

The available energy of expansion from 175 pounds to 1 pound is:—

$W = 254{,}000$ foot-pounds.

This gives a spouting velocity of $v = 4{,}030$ feet per second.

These are velocities far in excess of anything feasible in revolving machinery.

Four thousand feet per second is a velocity of 2,700 miles per hour. Going at this velocity we would travel around the earth three times in a single day. The velocity energy of a body going at this speed is four times that of a rifle bullet which penetrates 60 inches of oak planking, and is 600 times that of a tornado.

The problem, which had to be solved in developing the steam turbine, was to utilize such velocities mechanically. This is the feature which has retarded the advance of the steam turbine until the recent years.

The first successful attempt in designing an efficient steam turbine was made by DeLaval, a Swedish engineer, who had a great experience with high-speed machinery from his work on centrifugal apparatus.

By using extremely high peripheral speeds, 800 to 1,000 feet per second, and high numbers of revolutions, 10,000 to 30,000, he succeeded in abstracting by a single turbine wheel from a steam jet with single expansion from boiler pressure to condenser pressure, sufficient energy to give an efficiency comparable with that of the best reciprocating steam engines. Vast difficulties had to be overcome in reaching these results: at 800 feet per second, or 600 miles per hour, and with 10,000 revolutions per minute, the centrifugal force at the periphery of the wheel is 25,000 times the weight. That is, if the two sides of the rotating wheel differ in weight by a single grain at full speed the wheel would be unbalanced by 4 pounds. It is obvious that no refinement of manufacture can balance a wheel with such accuracy that it would not rack itself to pieces with such centrifugal forces. DeLaval solved the problem by making the wheel self-balancing. Instead of a short, solid shaft, a long, thin, and therefore flexible, shaft is used, which, by bending slightly, centers itself. That is, the DeLaval disc is a gyroscope making its own axis of gyration and so adjusting itself into the condition of centrifugal balance.

The difficulties of balance by gyroscopic action increase with increasing size of the turbine. Therefore the DeLaval turbine has been mainly built for small and moderate sized units.

The DeLaval turbine is an impulse turbine. Since the impulse turbine requires only half the peripheral velocity of the reaction turbine, where excessive spouting velocities have to be controlled, the impulse type obviously appears better suited.

Before the steam turbine could expect to come into general industrial use, however, means of reducing the peripheral speed were imperative.

A solution of the problem of lowering the spouting velocity of expanding steam sufficiently to use it economically in turbine wheels without very excessive peripheral speeds was found in the sub-division of the energy transformation into a number of successive steps. Instead of expanding the steam at once from boiler pressure to condenser pressure and so produce the terrific spouting velocities as calculated above, the steam is expanded in a number of successive steps,

each extending only over a part of the total pressure range and so giving only a part of the velocity, just as in the modern reciprocating steam engine, two or three, or even four successive expansion steps are used. That is, the steam is expanded from boiler pressure to some fairly high intermediary pressure, the velocity produced thereby used in a turbine wheel, and the steam leaving this turbine wheel is expanded again to a lower intermediary pressure, the velocity of this expansion used in a second turbine wheel, then the steam expanded still further, and so on, until ultimately, after a number of expansion steps or pressure stages, the condenser pressure is reached.

With n successive expansion steps or stages, each stage converts $\frac{1}{n}$ of the total energy of the steam into velocity. Since the velocity — energy is $\frac{1}{2}mv^2$, the v^2 is hereby reduced to $\frac{1}{n}$, and the velocity of v to $\sqrt{\frac{1}{n}}$ of what it would be with single expansion. That is, the velocity of the steam jet is decreased proportionally to the square root of the number of successive stages or pressure steps: four stages reduce the velocity to $\frac{1}{2}$, nine stages to $\frac{1}{3}$, etc.

Assuming then, that of the total available velocity, of 4,000 feet per second, 10 per cent. is lost by friction, etc., a velocity of 3,600 feet per second would have to be taken up by the revolving wheels. With a single wheel, maximum efficiency would require a peripheral speed of 1,800 feet per second with an impulse turbine, 3,600 with a reaction turbine.

With the modern development of high-speed machinery, peripheral speeds as high as 400 feet per second, and even somewhat higher are used in turbine wheels with perfect safety.

A peripheral speed of 400 feet per second gives best efficiency in an impulse turbine with 800 feet per second steam velocity, that is, the required velocity is 800-3,600, or 2-9 of the total velocity, and the velocity square, or the energy per stage, therefore $(2 \div 9)^2 = 1\text{-}20$ of the total energy. That is, 20 successive impulse turbine stages, or 20 successive expansions, each stage with a set of nozzles and a turbine wheel reduce the steam velocity of each expansion so far that it can be fully used in turbine wheels of 400 feet per second peripheral speed.

With a reaction turbine at 400 feet per second peripheral speed, the steam velocity must be brought down to 400 feet per second, that is, four times as many expansion steps, or 80 reaction wheels, are required.

The impulse turbine, requiring fewer expansion steps, therefore, appears superior, and considerable work has been done with fair success, mainly in Europe, on the development of such impulse turbines with very many single-wheel stages.

Diagrammatically, the steam path of such an impulse turbine is shown in Fig. 7: the steam exhausting from the preceding wheel A enters the system of stationary nozzles B in the partition wall C; in these nozzles it expands to a velocity equal to about twice the wheel velocity and at this velocity enters the rotating turbine wheel D. There it gives off its velocity, entering the shell E with just sufficient velocity to pass to the next system of nozzles F. The expansion in the nozzles B takes place down to the pressure in the shell E, that is, no pressure difference exists between the two sides of the turbine wheel E, and so no steam leakage and no end thrust on the turbine shaft.

Such a turbine requires as many compartments as stages and so is rather more complicated a structure than desirable.

A simpler structure is produced by combining nozzles and partition walls into a nozzle wheel, as shown in Fig. 8. Here, the steam leaving rotating wheel A, immediately enters at low velocity the stationary nozzle wheel

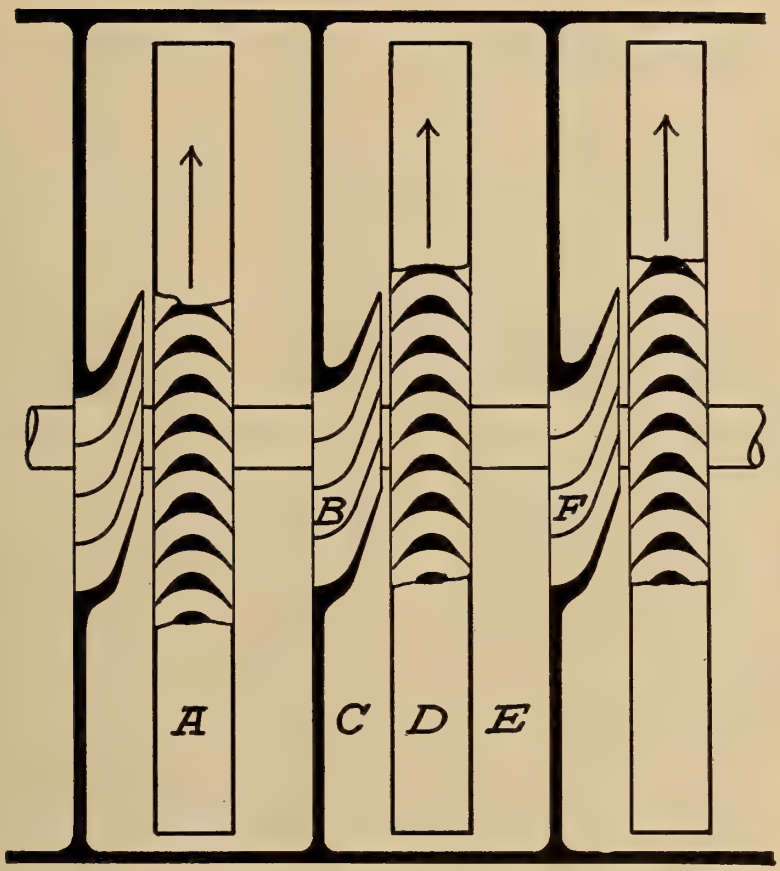


FIG. 7—MULTIPLE IMPULSE TURBINE

B, expands therein and gathers velocity, and with this velocity impinges on turbine wheel *E,* there loses its velocity and enters the next stationary wheel *F* at low velocity, etc.

In this structure, the stationary wheels *B, F,* etc., consume pressure and produce velocity, the rotating wheels *A, E,* etc., consume velocity and produce mechanical work. There also is no pressure difference and therefore no leakage around the rotating wheels *A, E,* etc., but there is a pressure difference and a steam leakage across the stationary wheels *B* and *F,* so that this structure is less efficient than the more complicated structure, Fig. 7.

The leakage around the stationary wheels is reduced by reducing the pressure difference, and thereby the steam velocity, that is, carrying the expansion in the stationary wheels *B, F,* etc., only to a velocity equal to the peripheral speed of the rotating wheels. In this case, the steam enters the rotating wheels *A, E,* at an absolute velocity equal to the wheel velocity, that is, at zero relative velocity, and expansion must take place in the rotating wheels also. This leads to the combination turbine sketched in Fig. 9. Here, the stationary wheels are nozzles, the revolving wheels, reaction wheels. This type has been developed by Parsons, in England, and by the Westinghouse Company, in the United States. It is the first type of steam turbine which has found an extensive industrial application, and has been very successful, especially in large units.

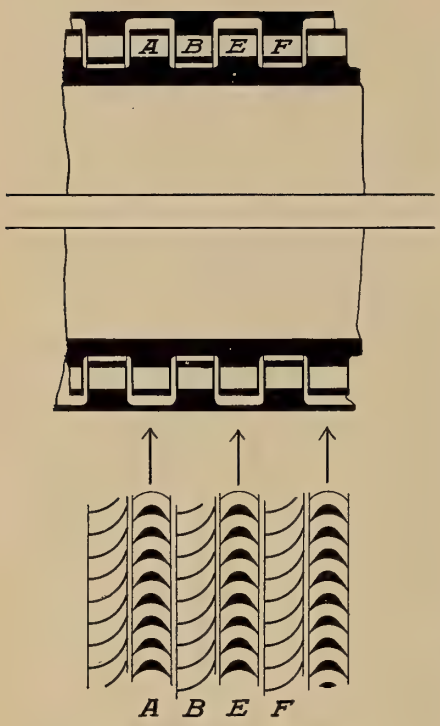


FIG. 8—MULTIPLE-STAGE TURBINE

The steam, entering the stationary nozzle wheel *B*, at low velocity, expands thereon to wheel velocity, gives off this velocity by entering the rotating wheel *E*, gathers velocity by expansion in the rotating wheel *E*, gives off this velocity by leaving the rotating wheel and entering the next stationary wheel *F*, and so on. Since in this type the expansion velocity is half what it is in the impulse turbine of the same peripheral speed, four times as many pressure steps are required, that is, if the impulse turbine, Fig. 8, requires 20 rotating impulse wheels and 20 stationary nozzle wheels, the combination turbine, Fig, 9, requires 40 rotating reaction wheels and 40 stationary nozzle wheels.

This type of turbine has pressure differences and thereby steam leakage across stationary, as well as rotating wheels, and since the pressures are different on the two sides of the rotating wheel, a pressure or end thrust on the shaft exists, which has to be counterbalanced. The main advantage of this type of turbine is the very low steam velocity, and, therefore, low relative velocity between steam and wheels, which gives low friction losses in the steam passages, its disadvantages the large number of rotating discs and blades which are required.

While by multiple expansion, that is, by the use of a number of successive pressure steps, the steam velocity can be brought down so far that it can be utilized efficiently without the use of excessive peripheral speeds of revolving apparatus; this requires the use of a large number of revolving wheels, that is, is bought at the expense of simplicity.

A very great reduction of the number of rotating wheels is produced by the introduction of velocity steps in addition to pressure steps as introduced by Curtis in the steam turbine which bears his name. Suppose, in a system of nozzles *A* of Fig. 10, the expansion is carried to a velocity *v* very much greater than twice the wheel velocity *s*, and this steam jet

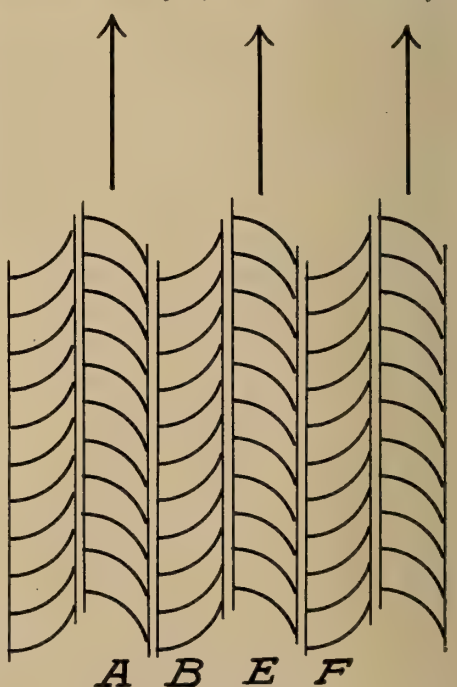


FIG. 9—PARSONS COMBINATION TURBINE

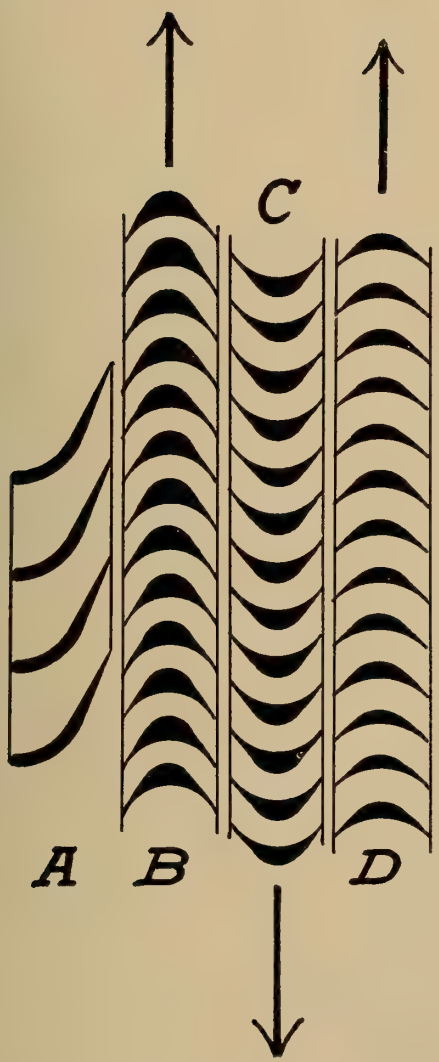


FIG. 10—COMBINED VELOCITY AND PRESSURE STEPS

sent into the impulse wheel *B*. The steam then leaves this wheel at a velocity $v - 2s$, which is still very high. This velocity, however, is not thrown away, but used by the steam entering a second wheel *C*, where the velocity is again reduced by $2s$, in driving the wheel, and the steam so issues at velocity $v - 4s$, to enter a third wheel *D*, and so on, until all the velocity of the steam is consumed.

Since the steam leaves wheel *B* in backward direction, wheel *C* would be set in rotation oppositely to *B*. That is, alternate wheels would rotate in opposite direction. To produce the same direction of rotation between successive wheels *B*, *C*, *D*, etc., stationary intermediates are interposed for the purpose of reversing the direction of the steam jet, as shown in Fig. 11. Here, the successive revolving impulse wheels *B*, *C*, *D*, are separated by the stationary reversing wheels *B'*, *C'*. Such a series of wheels and intermediates in the same expansion stage give no pressure differences, hence no appreciable steam leakage or end thrust, that is, although this structure looks somewhat similar to that of the combination turbine Fig. 8, mechanically, it is distinctly different in character.

As seen by n, successive wheels of speed s, traversed by the same steam jet, a steam velocity $2ns$ can economically be used, or, in other words, n successive impulse wheels in the same steam jet, or, n velocity steps, consume n times the velocity, or n^2 times the energy of a single wheel, that is, are equivalent to n^2 pressure steps.

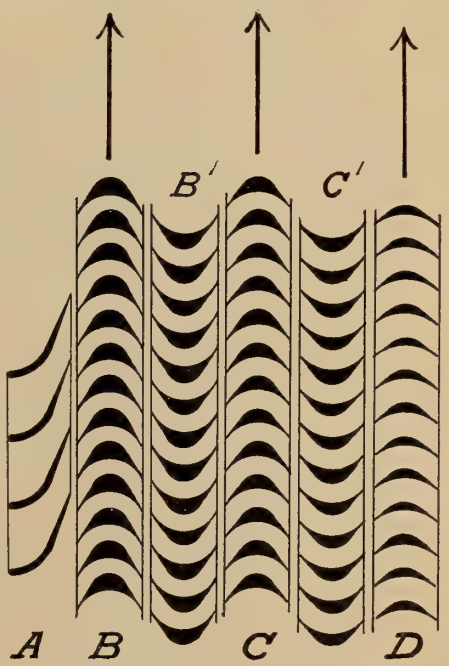


FIG. 11—SCHEME OF CURTIS TURBINE

The economical wheel velocity is, therefore, reduced directly proportional to the number of velocity steps, and only proportional to the square root of the number of pressure steps, or in other words, velocity steps are more effective in reducing the peripheral speed of the wheel than pressure steps. For instance, 5 successive velocity steps would give the same wheel velocity as 25 successive pressure steps or stages, and would so be more than sufficient for the whole expansion range from boiler pressure to condenser pressure.

However, with the increasing number of velocity steps, the steam velocity, and thereby the friction loss of the steam in the wheel passages increases, but at the same time the external wheel friction decreases, due to the smaller total number of wheels used, so that the maximum efficiency is given by using pressure steps or stages in addition to velocity steps. The proper distribution of the total energy between pressure steps or stages, and velocity steps or wheels per stage, required to produce maximum economy, is a question of design and so outside of this article.

For instance, in a two-stage three-wheel turbine, that is, combination of two pressure steps, each having three velocity steps, each stage is equivalent to nine single-wheel impulse stages, and the turbine with a total of six revolving wheels and four stationary intermediates, is equivalent to 18 impulse wheels, or 36 wheels of a combination turbine.

This combination of velocity and pressure steps as used in the Curtis turbine, therefore simplified the structure by greatly reducing the number of elements.

MUNICIPAL OWNERSHIP IN ENGLAND

III. MUNICIPAL OWNERSHIP IN ELECTRIC LIGHTING AND TELEPHONY.

By R. S. Hale

In the previous installments of Mr. Hale's comprehensive examination of the facts relating to actual experience with the municipal ownership of certain public utilities in Great Britain, the subjects of gas works, water supply, and tramways have been discussed. The present article takes up electric lighting and telephony, and concludes the investigation with a thoughtful summary of the whole question of municipal operation in the light of the data thus obtained. The judicial tone of Mr. Hale's articles renders them especially valuable at the present time, when the important subject of which they treat is generally discussed from a partisan viewpoint rather than with an unbiased endeavour to ascertain the facts.—The Editor.

ALTHOUGH telephones were the next public franchise after tramways, the peculiar condition of telephone franchises make it more interesting to take up electric lighting first.

This began in 1875-80, and the first act was of 1882, giving twenty-one-year franchises on purchase terms rather more liberally worded than the Tramway Act.

The difference between electric lighting and tramway business, however, made the terms really much more onerous for the former, since electric lighting was far more of a risk, and required a far longer time to develop the business than was required by the tramways in the centre of large cities. The result, therefore, was that no companies secured valuable franchises, and, that with the exception of people in rich country houses, or hotels or factories that were large enough to put in isolated plants, no English town, with one or two unimportant exceptions, got electric light at all.

In 1888, however, they saw that twenty-one years was too short, and the franchise time was extended to forty-two years. If five years be taken as the time necessary for developing enough business to pay some return on the first capital invested, this extension of the time was equivalent to an increase of the time from sixteen to thirty-seven years, or a decrease from an annual 5 per cent. to about 1 per cent. of tax on the difference between the real value, including risk, etc., and the future purchase price. Further, between 1882 and 1889, due to the strides made in America the risk had begun to disappear and the combined effect of les tax and less risk brought forth many private plants. It was not, however, until 1895 that the municipalities made any general move to give the people electric light, all the progress up to this time having come from private enterprise.

It should be noted that the purchase clause did not bear on the municipalities at all, that the municipalities had perpetual franchises and had to provide no sinking fund other than for ordinary depreciation. In spite of this, perfect freedom for municipal enterprise, from 1882 on, we find in 1890 the following towns of more than 200,000 population without electric light: Birmingham, Bristol, Dublin, Edinburgh, Glasgow, Hackney, Hull, Leeds, Leicester, Manchester, Nottingham, Sheffield, Salford. In 1895 the following towns of 100,000 population were without: Belfast, Birkenhead, Blackburn. In 1900 the towns of 20,000 were too many to count, and even in 1905 many large towns were still without supply.

Comparing this with America, where the franchises were free, and were either much longer or were perpetual, we find that in 1890 there were, in Massachusetts alone, companies in nearly every town of 20,000 population.

This is a remarkable testimony to the failure of municipal enterprise in England. To-day, however, now that private enterprise has shown the way,

municipal operation is fairly good as far as it goes. In London, for instance, where half the plants are municipal and half private, the average price of current is considerably lower from the municipal plants, and these are laying aside more for depreciation than the private ones. (See L. C. C., analyses of London electric works, 1902, 1903 and 1904.)

In certain ways the accounts are not quite correct, for instance, the municipalities probably charge themselves too little for taxes (5-10 per cent. on municipal as against 6-10 per cent. on private), and likewise on general expenses and management (.27d. per kilowatt-hour as against .34 for private). Part of the latter may, of course, be a genuine saving, due to such items as the labour of public-spirited citizens on committees, as against directors' fees, but some of it, like the drummer's overcoat, is probably in the city accounts somewhere else. On the other hand, the municipal plants have been built decidedly cheaper than the private ones. I thought at first that this might be due to charging the laying of the mains, etc., to street repairs, but the difference is fully as great on plant and machinery as on mains, and is probably due to the purchase by the municipalities by tender, while the private plants have, in many cases, especially in the earlier days, been promoted by manufacturing companies which sold their apparatus above the market price.

On the other hand, a very marked feature appears of some municipalities crediting themselves too much for street lighting. In England, partly from the fact that street lighting is but a small part of the electric lighting business (gas being far more used than in the United States), but chiefly from the more scientific method of account keeping, the accounts of the electric department are kept more as though it was a separate body purchasing its water from the water department, paying its taxes to the assessors, selling its current to the different public buildings and to the street departments. In Bermondsey, for instance, in 1905 the electric department charged the street department 4d. per unit for street lighting (the street department provides poles, etc., and trims), while in other neighbouring towns the private companies charged less than half, i. e., less than 2d. a unit. The excess amount changed a real deficit on the undertaking to a small bookkeeping profit.

While there are several cases like this, and while there is a very slight tendency to cook the accounts, especially in places that would otherwise show a loss; yet, on the whole, my judgment is that the municipal electric plants are actually supplying light cheaper than private ones, even after including in the cost the items that are not shown in the accounts. The difference goes into the pockets of the shareholders in return for the risk they run, i. e., as sinking fund for the risk and development cost. The question of depreciation is, of course, an important item in judging whether the municipal accounts are accurate, but the fact that the municipal plants, which have been running eight or ten years, are nearly all doing well is a reasonable indication that the ordinary maintenance and the statutory sinking funds have, on an average, taken care of the depreciation.

We find, therefore, in electricity as in tramways and in gas, that what the cities have done at all they have done well, but that even when given the opportunity they have failed to show enterprise anything like that of private ownership.

Some interesting statistics to show how the tax on private enterprise has checked development, are as follows:—It must be remembered that since 1882 the field has been absolutely open to the municipalities, that from 1882 to 1895 most of them could borrow money at 2½ per cent., or even better, and that in the early years of electric lighting, England

was far more ready than the United States, so far as apparatus was concerned, due to the greater use of the steam engine, and to the fact that the great English electric cable factories had been developed by the perpetual franchises for submarine cables:

	Population Supplied.	16 C. P. Electric Lamps.	Customers.
Boston	600,000	1,100,000	15,000
Glasgow	800,000	403,000	9,324
Manchester	659,000	300,000	5,171
Edinburgh	332,000	336,000	7,129
Leeds	444,000	154,000	3,988
Birmingham	522,000	113,000	2,374
	2,757,000	1,306,000	27,986

Or, comparing Boston with other corresponding English towns, thirty people out of every 1000 take electricity in Boston, as compared with ten in England. If the claim be made that these English municipalities sell cheaper than Boston, it is clear that the Boston Edison Company gives more for the money. No one is obliged to use electricity in Boston and it would be absurd to say that all the people who take electricity in Boston, but who correspond to the people who don't take it in Glasgow, are doing so for the benefit of the Boston Edison Company, and not for their own benefit.

English prices cannot be exactly compared with those in the United States for several reasons.

1. Labour is much better paid in the United States.

2. Much of the material costs less in England, on account of free trade. The capital-cost and interest charges are therefore lower per unit sold.

3. The supply in England is chiefly at 200 to 250 volts, the customer buying his own lamps, while in the United States the supply is at 100 to 125 volts, with free lamps included in the price. This makes a difference of about 20 per cent. in the cost of light for the same cost of current.

The fact that in England the average price of electricity is higher in the privately-owned plants than in municipal is not necessarily testimony to the skill of the municipalities, since these pay only 3 to 3½ per cent. on their money and want no return for the risk they run, but the difference figures out a serious tax on a large portion of the population who do not use electric light.

Whatever the difference in price between municipal and private plants it only helps to measure the amount that all the customers who would have been supplied by private enterprise, but are now left without a supply by municipal enterprise are actually losing.

The true amount lost by the check to private enterprise, of course, is far more. There can be little question that a great majority of the customers of either private or municipal plants would pay higher prices if they could not get the electricity otherwise; the fact is undeniable when we look at the reductions in price that both private and municipal plants have made. In the English municipal plants ten customers for each 1000 of the population are saving 10 per cent. or so, due to their municipality having invested in a risky business that turned out well. The other twenty customers for each 1000 of the population that, according to American experience, ought to-day to be using electricity would be willing to pay at least 10 per cent. more, and probably 30 or 40 per cent. or 100 per cent. more rather than go without, yet they do go without by reason of the lack of municipal enterprise, and are losing this difference either in comfort or in profits on their personal business.

It takes many years for all the results of a bad law to show, and though the results of the 1882 law for a twenty-one years' franchise, were so bad that it had to be changed in 1888, yet the 1888 law still remains on the books.

Since 1900, however, all the important franchises have been granted; not by this act, but by special acts, and are perpetual franchises. The

forty-two years' term, especially after the United States had shown the way, furnished opportunity in the densely populated districts. For going out into country districts, however, and building up a business for which the company would often have to wait ten or twenty years to show a profit, a business, too, on which the margin of profit was very small, forty-two years is too short a term.

It is important to notice this difference. In the case of a new business there is a big risk and usually a chance for a big profit. Frequently there will be found people who have confidence in the future and are willing to take risks for a smaller profit than is really justified. We are so apt to judge the past by the present that it is difficult to understand that many of the people who bought Calumet and Hecla stock at $15 were no wiser (though they were luckier) than the people who bought Arcadian at the same prices.

The question of development is always present, while the question of risk is less important in the latter years of a business. When the results of a business may be prognosticated at a sure 4 per cent., but no more, the tax of 1 per cent. or ½ per cent., represented by a purchase clause that does not regard the losses (including loss of interest) during development, becomes an absolutely prohibitive tax, since the inventor sees no profit. Further, it is not the actual risk, but the ratio of risk to profit, that an investor looks at, and when the possible margin of profit is small, a small risk is as deterrent as a large risk set against a large possible profit.

The feature I have just spoken of, that there are always certain investors, who are rasher than their fellows, explains some of the cases of good development under the tax of limited franchises. If one investor feels that the chance of electricity paying 12 per cent. is an even shot, he will figure that he can make the consumers pay a 2 per cent. sinking fund on a limited franchise and consider it as a 5 per cent. proposition, even if some of his neighbours, or all of them, consider him unduly rash.

This also explains why a purchase clause, even at market value, is onerous if the time it comes into effect is short. A purchase clause at market value is a purchase clause at such a price as the ordinary purchaser would give. A man starting a new business, however, takes up something that the ordinary man has, up to that time, thought worthless. If he spends time and money to develop it he will not be willing to dispose of it at any price that the ordinary man thinks fair, because the reason he starts the business is that he thinks the ordinary man's judgment wrong. However, he will be willing to have a purchase clause at market value after a period long enough to prove his own soundness of judgment, provided, as said before, the arbitrators are to consider all the elements of value, and the sale is to be compulsory, whatever the price.

I may return a moment to this element of chance, since it is this element of risk that causes most of the hard feelings about public franchises, or rather it is the failure to recognize the risk of the past, now that the present has shown there was no risk.

Take, for instance, the case of land, which, as agricultural land, is practically worthless. Supposing a geologist, by careful study and investigation, judges that it is worth fifty times that amount as oil land, but buys it as farm land, then digs several wells, and, finally strikes oil. No one grudges him his profits. On the other hand, suppose the owner of a neighbouring farm is abroad, and after oil has been struck his land is more valuable, but a speculator cables a friend and they buy this land as agricultural land, it is regarded as sharp practice. The farmers in a neighbouring district hear of it and refuse absolutely to sell their land at all. The result is

that no one will dig a well at all in that district, or even if a few farmers dig wells themselves they do not, except by luck, strike the oil and the district falls behind.

Of course, the farmers in the neighbouring districts may say: "If the oil is there it will stay there, and when we get around to it we will explore thoroughly for it ourselves." When they take this position, however, they forget the immense power of compound interest, at 3 per cent. money doubles itself every twenty-four years—at 6 per cent. every twelve years. If the municipality lets a franchise lie idle, or the farmers refuse either to drill for oil themselves or to let anyone drill, then those idle rights must double in value every twenty-four years or twelve years to give only 3 per cent. or 6 per cent. on the investment. Some great fortunes have been made by the so-called unearned increment of land or franchise, but the cases where idle land or idle franchises have increased in value sufficient to pay even 3 per cent. annually on the value are rare, and I venture to assert that in not one case in 100 will it be found that to let property be idle in order to gain the unearned increment has paid as much as to sell and invest at 3 per cent. compound interest.

In 1900, England began to realize that the forty-two years' franchises for electric light checked development and began granting, by special acts, so-called "Electric Power" franchises for large areas that differed from the former franchises in two features:—First, the franchises were practically all perpetual; second, the insertion of the sliding scale principle that has already been referred to in the case of gas. The time is short since the policy was changed from forty-two years to perpetual franchises, yet, as showing that the backwardness of England in electric matters has been due more to her restrictive laws than to lack of enterprise, it is interesting to note that one of these perpetual franchises, viz., that at Newcastle, is already supplying nearly as much electricity in proportion to population as any town in the United States supplied by steam power.

We may next turn our attention to telephones.

Telephones started in 1875-1880, but were in England declared at the start to be a part of the English Government monopoly of the post and telegraph. Nevertheless the Government would not, and, due to this declaration of monopoly, private enterprise could not, take them up. Finally, however, franchises for about thirty years were issued to various companies. On account of the necessity of handling telephone business as a whole, these soon consolidated into one company.

The franchises which were, of course, subject to the ordinary taxes on all property, were also saddled with the sinking fund rendered imperative by the limited franchise, and with an extra tax or post office royalty in addition. As a natural result the development of telephones is comparatively small and the price comparatively high for the service rendered.

The Government took over the trunk lines in 1896, and in 1911 is to take over the whole plant at plant value.

About 1900, several municipalities acquired licenses to supply telephone service in their local areas, generally in competition with the National Company, but in one case, Guernsey, the municipal service is the only one.

The cases are so few that no general conclusion can be drawn. Guernsey seems to show that there is nothing that prohibits a municipality from showing enterprise, as they seem to be furnishing a good service to a large number of inhabitants at a low rate. The rate payers have had no return for the risk they ran of the plan failing. While it is hard for an outsider to judge, I may say that the appearance of Mr. A. R. Ben-

nett's name in other connections indicates that Guernsey is one of the places where the municipality were fortunate enough to get an able, skilful, and enterprising manager, and wise enough to leave the development to him.

In Tunbridge Wells the telephone plant was a failure, and was finally turned over to the National Company.

In other towns, as Brighton, Glasgow, etc., the experiment is still going on, and the competition has apparently reduced the charges. In these cases, unlike the tramways and electric light, the municipalities are competing under the same terms as private enterprise, since the Post Office is to take over their plant at the same time and probably on the same terms that it takes over the companies. It will, therefore, be of interest to see what the result has been in the years when these municipal franchises expire.

On looking over the history of municipal franchises, therefore, we find a mass of data, from which certain broad general principles appear to arise.

1. In the case of a new business the municipalities will not undertake the enterprise. Before trunk roads between towns became a necessity, they were built by turnpike companies. Before water supply became a necessity only a dozen cities built their own waterworks. Before gas became a necessity very few towns built gas works. It was only after private enterprise had shown the way, that towns built electric plants or tramways. No town built telephone lines until private enterprise had shown the way.

This feature appears to be universal, and no wonder. A new enterprise is always a risky one. The average man will not risk his money in order to supply other average people with something, whether gas or electricity or telephones or steam heat or compressed air or electrical distribution of music from a central music machine, that the average man has no experience of, and since municipal action is dependent on the feelings, opinions, and votes of the average man, the municipal councillor will not run risks that his constituents think unwise.

I realize, of course, that where the City Council are elected by one class they may spend the money or risk the money of another class, i. e., where the voters are not taxpayers and the taxpayers are not voters. While, even to-day, the Council in but few cities really represents the taxpayers, yet there is and has been no very great tendency for the Councils to indulge in speculative undertakings. The non-representative councillors do show a tendency to waste money in high wages and unnecessary comforts, such as Turkish baths and mosaic pavements for the poor, but they do not show any tendency to incur large risks. We see few signs of Councils experimenting on wireless telegraphy, or flying machines, or on building street railways into uninhabited districts. The London County Council experiment on Thames steamers is almost an isolated case.

In other words, the whole history of the English municipal activity shows that the municipalities will not undertake risky enterprises or new businesses.

The few cases where the municipalities have shown any enterprise, will be found usually to be due to the presence of what we may call "one-man power" to the presence in the Council, or as engineer or manager of an able man who has dominated his fellows. In other words, to individual, as distinct from municipal, enterprise.

2. The history of English public franchises shows that where private enterprise has been allowed free sway it has done the work and done it well and has made money at it.

Private enterprise built British roads and bridges and waterworks and gas plants and made money at it. How much money, of course, is a

question. Undoubtedly less than appears, because the apparent profits are figured only as a percentage on the capital invested in the successful enterprises, while the true investment should be figured as the total, both of the existing capital and those items that have been marked off the books.

3. History of British municipal work shows that when the municipalities have undertaken a work they have done it well, and even better than private enterprise, but only very slightly better. They have been limited, they have not branched out or grown in anything like the degree that private companies have done. The fortunate individuals that get municipal service are well served, even if the unfortunate citizens whom the municipalities will not take the risk of serving have to do without. The slight difference that exists between municipal service and private service is clearly due to the fact that the private investor wants some return for the risk he runs, while municipal accounts are all made up on the basis of there being no risk, and when the municipality incurs a loss on a particular trade, they explain it by saying, as in the case of water, that they desire the people to have it at less than cost.

4. There have been no cases where municipal enterprise developed new businesses; in fact, there probably never will be, because a new business, almost by its definition, is something the average man, hence the average voter, thinks will be a failure.

5. The English have tried in three experiments, viz., tramways, electric lighting and telephones, to secure the benefits of private development while still reserving to the municipality the right to take over the business at some future date at less than its market value. Each of these experiments has resulted in checking private enterprise and in placing each of these businesses far behind the United States in development, and has been given up in favour of perpetual franchises.

6. The present trend of English practice is in the line of encouraging municipalities to take up what activities they will, but that whenever a municipality will not or cannot or does not take up a particular business and really develop it, to permit private enterprise to take it up on terms such that the lowest possible price made, be made to the user from the start and the greatest possible development of business encouraged, i. e., English practice is to-day to give franchises with clauses limiting the price to be charged for the service, either alone, as in the case of railways, or in connection with a sliding scale of dividends as in the gas and electric power, but of giving perpetual franchises with no purchase clause or a purchase clause at market value as a going concern.

In a visit to France I obtained but few data—enough, however, to indicate that to obtain complete data would take a very long time.

Apparently, in France, all franchises, railways, tramways, gas, electric light etc., are granted as limited franchises from ten to ninety-nine years, and at the end of the franchise the business becomes the property of the State, either for nothing, or at something under its true value. Each franchise is the subject of a separate arrangement, the terms varying in each case.

The result agrees exactly with English experience; the development of gas, tramways, electricity and telephones and of all their public business is far behind what has occurred in the perpetual franchises in England and the United States, though not so far behind the English limited franchises.

What Government does is fairly well done in some cases. French porcelain from the Government factory at Sevres, the French vichy from the Government springs, and the Government-aided French opera and theatres are famous, but these are either done at a loss or for less profit than if in private hands. French

matches and French tobacco are also well known.

English municipal government is criticized in England in many ways, but a few criticisms are passed on the honesty or well-meaning of its members. The taking of bribes or secret commissions or secret profits for individual officials is, I should judge, almost non-existent, at least as compared with some American cities.

It is hard to give the character of Councils in figures, nevertheless the following may be mentioned:—In the Glasgow Council of 1904 we find six members had served twenty years, twenty-one members had served ten years, nineteen members had served five years, and only thirty-one members had served less than five years, showing that on every committee there must have been several men who knew the enterprise thoroughly. There were sixteen members who paid taxes (Anglice rates) on a rental of $2500 a year or more for a part of their real estate alone, and only twenty-five members who paid taxes on a rental of less than $500 a year. In Leeds and Manchester, where I had similar tabulation made, the results are substantially the same; and in general the men who serve on the English municipal bodies are quite a different class from those who serve in some American cities.

There are certain other features of municipal enterprise that are worth discussion.

Part of the failure of municipal enterprise, is due, not solely to weakness in the municipal idea, but also to unfortunate electoral machinery. The economic areas of supply do not, except by accident, coincide with municipal boundaries. Thus, the water area, tramway area, gas area, electric area, police area, sewer area may be, and often are, all different. A tramway area or telephone area usually covers several municipalitites, while the area for distribution of cold from an artificial ice plant is very limited. Whenever the municipal area and the economic area for the service in question coincide, the question is simple. Whenever they do not, then in order to get the best results, either one of the municipalities must undertake the work for the rest or else there must be joint action.

For one municipality to do work for another is substantially the same thing as private enterprise. There is no reason, for instance, why Boston should expect any greater enterprise or greater skill in supplying gas from the citizens of Everett than from the New England Gas & Coke Company, and in some cases in England where a municipality has acquired a gas supply the citizens of adjacent suburbs have felt that they got decidedly better treatment from the private enterprise of a stock company than from the private enterprise of another municipality.

In some cases joint boards have been tried and found a success, and it has usually not been difficult to form joint boards to conduct established or clearly defined businesses. In practically no case, however, has any joint-board scheme between two or more municipalities been a success for establishing a new business. This is not a feature peculiar to municipalities. With the exception of the gas works for the Fall River cotton mills and one or two similar enterprises, I know of no cases where two or more companies, or even individuals have combined for a joint supply. In nearly all cases it has been necessary for private enterprise, usually in the form of a new stock company, to undertake the work.

Though the difficulty of combining several municipal bodies into a joint board is not so very much greater than that of getting several stock companies to act in concert, yet it is a difficulty, and English experience thoroughly confirms the idea that to limit the enterprise only to cases where the municipalities themselves are ready to act is a very serious check on the interests of the public. Supposing, for instance, Boston, Somerville, Cambridge, etc., each had

their own plant for gas supply, would the municipal bodies have ever gotten together to get the economies of joint action, until the time came, as it did in the case of water, that gas supply became universal.

Another feature of municipal enterprise that has often been referred to is the danger of building up political machines or trades unions. While this danger undoubtedly exists I cannot see any particular evils as yet, resulting from it in England, or rather no evil applying to municipal trading ventures as distinct from school teachers or other municipal employees.

Much has also been said about the danger of single control, for instance, that a municipal gas supply with municipally-tested meters would be a danger. I cannot see in England any sign of this feature, in fact there seems, if anything, to be greater confidence in municipal operation direct than in private operations with municipal control. This, of course, only confirms the conclusion come to above, that English municipal operation is usually better than private operation, and that the only advantage of private operation is that it accomplishes the work and gives the people tramways and gas and electricity; while, on the other hand, when private enterprise is hindered the result is that the people walk and go to bed in the dark, even though the municipalities are free to supply them.

It is interesting to note that while England has gone far in socialism; yet, that in some cases, not only trading, but every function of government has been left to private hands, and that these private hands have, in at least one instance, made a mistake, similar to the English Government mistake, of limiting the franchise on telephones, tramways and electric light.

I refer to the chartered companies. The old East India Company, which came to an end about 1850, was a pure stock company, as much as United States Steel Corporation, but the East India Company appointed governors, made laws, raised and managed armies and navies, waged war and made peace, made courts and dealt out justice in a territory greater, and for a population far larger, than the United States. The North Borneo Company, the Rhodesian Company, and others are doing the same to-day. In this they are only following the principle indicated in municipal affairs. When a government or municipality is ready to undertake any work it will do it as well as private enterprise, but if government is not ready, it is better to let private enterprise do it than not to have it done at all.

The mistake made by the Rhodesian Company may not be a mistake in the end, since with them it is a case of stockholders' profits as against the development of the country as a whole, but their franchises for mines called for a payment of half the mine stock, or, in other words, of half the net profits. The result, of course, was a tremendous check, since the miners will not invest except in the safest and surest prospects, just as the investor will not build public service plants under limited franchises except in districts where he is sure of a return.

If the Rhodesian Company had thrown the mines wide open, they would have perhaps made less money for the Government, in this case the stockholders, but the country would have developed far quicker, and the country, as a whole, would have been richer and better off.

This perhaps brings out the perpetual problem of public franchises. The quickest development comes if they are given away: the more restrictions there are the slower the growth. When a service is completely developed, as in the case with streets or water to-day, then the municipality can wisely assume the operation.

But when it takes them over it must, of course, take them at market

price. If the municipality has granted a perpetual franchise and then starts to regulate prices or to take the property at less than market price, it is stealing, pure and simple. If it grants any limited franchise with a purchase clause at less than market value, this is equivalent to a tax on the users of the service, which checks development and is against the interest of the community.

Much has been said about the appalling increase in local debt and local taxation in England and many statistics have been published on this subject. In order to see whether this is a danger and whether it is connected with municipal trading, it is necessary to divide both debt and taxes into three classes.

1. Expenditure for such items as streets, sewers, etc., that bring in no direct return, but which add to the value of the property as a whole. For instance, take a lot of land worth $1000, letting for $30, and on which the rates are $10, so that the tenant pays a total of $40. Now, if a street near by is widened and a park built, the value of the land will be increased, say, for example, so that the tenant will be willing to pay a total of $60. If the interest on the city's debt raises the rates to $20, the landlord gets $40; and, although the rates have gone up from any point of view, the expenditure has been a wise and profitable one. Such expenditures as these need not be for permanent improvements alone. An expenditure for a band in a seaside resort is of this nature. The only question is: has the expenditure caused an equivalent increase in the values? Unfortunately this can seldom be answered exactly, because of the impossibility of assigning changes in value to any particular cause, but it is obvious that an increase in debt or rates is not necessarily dangerous.

2. Expenditure for poor rates or charities. Any increase in poor rates, pure and simple is an obvious evil, but it must be remembered that the line of demarcation between a poor rate and an insurance is difficult to find. The deserving poor are, by definition, people whose merits are such that, under normal conditions, they would be self-supporting. To relieve such temporarily, is exactly the same as paying a sum of money to a man whose house has burned down.

The principle of support of the poor undoubtedly lies in this feeling. A community is willing to contribute for the poor, or for education of the poor, because each member feels that he or those he cares for may some day be in need of the same relief; just as the mill owner pays for insurance, because he feels that his own mill may burn down some day. The danger in poor relief or in insurance lies, of course, in destroying incentive to work or save. If the payment for insurance is more than the mill is worth, the mill owner will take no precaution against fire, and lets his mill burn. If the poor man can get better living at the poorhouse than he can earn by his own efforts, under normal conditions, he will not trouble to work. There is, of course, no absolute line. If a mill owner gets the whole value of his mill he will take no interest in preventing a fire. If he gets half the value back from the insurance company, while he will be interested in preventing a fire, yet his interest will be by no means as keen as if he were to suffer a total loss.

In certain forms of insurance the principles are entirely different, since often an insurance company can, for various reasons, prevent fires or losses at less cost than the owner. An insurance association like the Factory Mutuals of Massachusetts, undoubtedly, by its engineering skill and advice, prevents far more fires than are caused by the diminished interest in the individual members in preventing fires, due to the fact that they will lose less than if not insured. While foreign to our subject I mention this since otherwise my remarks might be taken as

an attack on the insurance system.

3. Expenditure for so-called reproductive undertakings like gas, tramways, etc.

Taking a reproductive undertaking as one that is meant to pay its way, it is clear that if it does pay its way there is no danger from increase of the debt for that item.

It is much like a company. So long as it is really earning dividends no one objects to seeing the capital increased.

This division of the expenditure into these three heads, answers at once much of the arguments about increase of debt and rates, since it is clear that increase of debt per se is of no danger, the only question being as to whether it has been properly spent. So long as the expenditures for streets, parks, etc., have really increased the value of the whole city more than they have cost; so long as the expenditures for poor rates charities and their equivalent have not checked the incentive to work and save; so long as the expenditures for reproductive undertakings have been reproductive, then there is no danger.

But, on the other hand, if there has been waste in any direction then there is danger. For instance, if New Bedford and Fair Haven have spent $5,000,000 on a bridge that only adds $1,000,000 to the value of the two towns, there is danger. If poor rates have checked the incentive to work, as the English poor rates are said to have done previous to 1834, or if the reproductive undertakings are not really reproductive, then there is danger.

English statistics furnish but little information on these points; nevertheless, there are a few instructive lessons to be drawn.

In the Municipal Year Book, 1905, are given the rates for a number of towns, and also the debt, non-productive and reproductive. Further, the profits on the various reproductive undertakings are given. In comparing two towns there are often accidental differences, but when we come to eighty or more, as in this case, accidental differences begin to cancel out, and the averages are often of value.

I do not mean to assert that averages are in any sense conclusive arguments, but they do point to causes. If we find, for instance, that on taking the averages for different five-year terms for the last twenty-five years that Yale has always beaten Harvard in football, it does not prove that there is any advantage in having four letters in the name of the college rather than seven, but it does point to some difference between them so far as football is concerned.

Now in analyzing rates, debts and profits, we do find these curious distinctions. We divide them into three classes:—

Towns.	Profits Claimed.	Average Net Rate Excluding Poor Rate.	Total Expenditure in Terms of Rates.
48	less than 6d—average about 2d 1/2	6s 0½d	6.3
18	6d to 1/—average 6d	5s 10d	6.7
18	Over 1/—average 1/3	5s 6d	6.9

Now, I have spoken before of the question of the accuracy of accounts. If a town tries to show a profit in the electric works by charging the salary of the secretary to general expenses, or by overcharging the street department for lighting, then the other town expenses go up.

From the above figures it appears that the towns that make the biggest profits have the largest expenses, but that the difference is not as great as the profits claimed. We may, therefore, conclude that the greater portion of the profits claimed are genuine, but that a portion of the profits are not genuine ones.

It must be remembered, however, that there is a difference between showing a false profit and concealing a loss. If an electric light department is showing a profit, the other city departments will not willingly

contribute to that profit by assuming expenses that really belong to the electric works. If, however, the electric department is showing a loss, the other departments will be far more inclined to help it out.

To test this I have compared the rates as follows, on the basis not of profits claimed, but of total so-called reproductive work carried on:

		Number of Towns.	Rates Excluding Poor Rate.
Reproductive debt less	50 per cent of assessed rates	11	5/2
50 per cent	100 per cent	16	5/5
100 per cent	200 per cent	25	5/8
over	200 per cent	26	6

From which it appears clear that a large investment in reproductive undertakings is accompanied by a high rate, and vice versa, and again the figures indicate that expenses have been charged to other accounts that properly belong in trading accounts.

The poor rate is excluded because it is administered by another body than that which administers the other departments.

Miss Alice Lee's investigation, reported in Darwin on Municipal Trade, p. 209, does not agree with this, but her work may not have been based on so complete data.

The higher rates in towns that do much trading may be due to so many causes that it is hard to form any conclusion. It may indicate that losses on so-called remunerative undertakings are being concealed by charging them to other departments, and this is probably part of the difference. It may mean that the investment in municipal undertakings, by checking private enterprise has checked the growth of the town and made the ordinary expenditures a high rate per pound, or it may be that large investments in reproductive undertakings have caused waste in other directions, due to less careful management by the Councils.

It must be remembered that some, at least, of this so-called reproductive debt in these statistics does not properly come under that head, but, like the expenditure for baths, streets, etc., is not intended to show a direct profit.

Allowing for this item and remembering the rough comparison of municipal and private prices for gas, electricity, etc., I come to the conclusion that while the difference in favour of the municipal prices is not as great as claimed, yet that even after charging to municipal operation all its expenses, the consumer and taxpayer are a shade better off under municipal operation, but only very slightly.

The non-consumer is, of course, very much worse off under municipal operation. He pays the higher taxes, but does not get any other advantage.

The reason of the lower prices under municipal operation is, of course, the fact that the municipal operation is limited to the safe undertakings where there is no risk and private capital must be paid for risk.

Another danger said to be in municipal activity is that often referred to as direct employment of labour as against contract, and this, of course, furnishes opportunity for waste. As I have already pointed out, however, while this is an important question for municipalities, it may easily be considered separately from municipal trade, and applies often to company work as well as the municipal.

It is a curious and very important fact, that the cities which have gone most extensively into trading are at a standstill, so far as the growth of population is concerned, while the cities which have left tramways, gas, electricity, etc., to private enterprise, are growing comparatively fast. In other words, many English cities went into municipal trading in the past, but the citizens of these cities

are now moving into towns where private companies have control, the reason probably being that under municipal ownership, the service, while cheap and good, is limited, while under private ownership, the private companies have a financial interest in extending their service and promoting the general good of the city as a whole.

My investigation into English municipal trading, therefore, shows clearly:

1. That under English political conditions, with the class of men they elect to the Councils and keep on them, that what work they do do is as well, and possibly a little better done than under private management. Whether the class of men that run American cities would do equally well is another question.

2. That under English conditions the municipalities, while they do what they do do well, show very little enterprise or initiative in new work, and that

3. In order that the people may have the advantage of new public services as they develop and grow, that private enterprise must be depended on.

4. That private enterprise will not do the work unless it sees a chance for a profit, and a good one.

5. English experience covers attempts to gain the advantage of private enterprise at the smallest cost by means of limiting the profits (gas and water act, 1847), which has been a failure. By limited franchises (tramways 1870, electric light 1882 and 1888, and telephones), and this has been a failure, and has settled down, for the present, at least, to the sliding scale and auction clauses, so far as they can be applied, and to perpetual franchises for all new developments.

6. In America, as already shown, the regulation of rates so as to limit earnings has the same, or even worse effect, than a purchase clause.

While the power to regulate rates so as to prevent discrimination has always existed under the common law of England as well as in the United States, yet the use of this power so as to limit earnings without necessarily affecting discrimination is a new development.

English experience clearly shows that if American rate regulation should limit earnings unfairly, below the normal percentage on the market value of the public franchise properties, the final result will be a serious check to the growth of the country and the happiness of the people.

Under rate regulation in America, as has happened in England under laws that had a similar effect, a few people will get cheaper service, but more people will get none at all.

INDUSTRIAL AMERICA

A MACHINE-SHOP REVIEW.—I.

By J. E. Livermore

We have given, in recent issues of this magazine, a review of the impressions made upon an American, of the workings of municipal ownership in England, and as a fitting complement to this we offer the following interesting comments upon American machine-shop conditions by a British workman. Mr. Livermore spent several years in the United States, in active work in several important establishments, and the record of his impressions cannot fail to be of interest, both in England and in America. We are indebted to Mr. H. F. J. Porter, Industrial Engineer, of New York, for the use of the photographs from which the illustrations to Mr. Livermore's paper have been made.—The Editor.

TO those who work in the machine shop, to those in charge of the works, and especially to those who contemplate working in a machine shop, I would respectfully ask the perusal of the following lines. From the autumn of 1901 until spring of 1904, I spent my time at work in various machine shops in the United States of America. Being a stranger in a strange land, I made many notes of what was going on around me, and as I spent my time chiefly with that much discussed man, the American workman, I have been able to get together some notes which may be interesting, if not useful, and I propose to set them down as I found them. Many papers, both technical and daily, have said a great deal on the merits of this particular person, and much discussion has been caused on the same question, so much indeed, that to-day the American workman in the engineering trades is very much to the front, and not a few have gone to the States to see and enquire into the conditions under which this man works. I am not quite sure whether all the praise is due to the American workman (and by that term I mean the men who work at the bench, the forge and the machines). It has occurred to me that he is rather the product of an elaborate system of manufacture. He is not a genius, but he is smart, quick to take advantage of anything that turns up, and always on the lookout for something new. When he has a new machine in the shop he does not pass it by, he gets around it, looks it over, watches it work; maybe there is something on it he could improve, and which would mean dollars, and it is certainly the nature of the American to go one better every time. My first impression that I formed was that the American was distinctly the cleanest workman I had ever seen,—by this, of course, I mean workmen as a whole, and not individual men. When I had been at work for about half an hour on my first day, I ventured to remark that the men looked smart for workmen. My friend did not answer but gave a strange look at me; the next moment his eye was following the file which he plied vigorously, and which later on he informed me earned him from 40 to 45 cents per hour, he being on piece work. A little later on I enquired if the young men at work round about were gentlemen apprentices. "Well, I guess they are gentlemen," was the reply. The tone

LOCKERS AND SHOWER BATHS FOR THE FOUNDRY OF THE BROWN & SHARPE MFG. CO., PROVIDENCE, R. I.

LAVATORY, WESTON ELECTRIC INSTRUMENT CO., NEWARK, N. J.

WASH ROOM, LOCKERS AND TOILET J. H. WILLIAMS & CO., BROOKLYN

of this answer compelled me to ask another question, and I said that I did not doubt but what they were gentlemen, but what I meant was, had they paid a large premium to learn their trade. My friend informed me that they had not; indeed they were the ordinary run of apprentices and nothing more; all of them at work on the same terms. Twelve o'clock came and the whistle blew for dinner; not one of those 5-minute blasts which one hears so much in the North of England and which goes on booming until every man is clear of the works, but a sharp, clear note of about 20 seconds duration, and every man immediately took off his overalls and went with all speed to the washroom.

This department of the works one finds all over the States; every man washes before he leaves, and he does not go home in his overalls. Generally there is a good supply of hot water, and while 5 cents is occasionally taken out of the wages envelope to pay for soap, each man in most shops finds his own towel. At the end of the week the dirty towel, and the suit of overalls, are rolled into a bundle, and a ticket with the man's name written on and the name of the firm, with the articles to be washed is put through the string, and on Monday morning when the men go to wash for dinner each man takes his bundle to an appointed place in the washroom, and from there they are collected by the laundry van. The firm arranges for the washing and pays the laundry bill each month, and then deducts the amount from the wages, charging only the actual cost for washing. The clerical portion is undertaken by the firm free of cost. The clean suits are returned on Friday and a boy is appointed to sort and deliver them to each man in the various departments. On the outside

of the bundle is the ticket which was filled in on Monday with the man's name and his number at the bench, and the name of the department, and as every man (operators included) has a drawer in the bench it is quite an easy matter to distribute these correctly, while inside the clean bundle will be the ticket for the next week's wash. This washing business for the men is undoubtedly a part of the shop system and does away with stopping machines 5 minutes before meals, which, in some shops, is a very serious matter when it is reckoned up at the end of the year. There is no excuse to offer when you are caught, and it is a distinct help to the foreman in helping him to see that no time is wasted.

When the men return to the works they all enter through the washroom, and adjoining that is the room set apart for leaving their clothes. A square card gives the man's name and his number, and underneath he will have about four hooks; one for his hat, one for his overcoat, one for coat and waistcoat, and lower down near the ground is a fourth hook for odd purposes. Having left his clothes his next move is to the floor or department in which he is at work. Here, as he enters, his time is registered by a recording clock, and when this is done he is ready for work. Time recorders are everywhere, always close to where the men work, and, as they are paid strictly by the time recorded, every man takes care to be in in time, consequently each one is at his place when the whistle blows, all ready for work, which he begins promptly, and at the same time the foreman's clerk closes the cases containing the keys, or cards of the recorder, so that if any one is late, he loses an hour. There is no grace, no free 5 minutes, you are either on time or you lose an hour. These cards, or records, are all carefully filed, and as they contain the man's name, his number and his time, registered by the clock each day, and the date, there is no need to consult any second person to find out

FACTORY LAUNDRY, NATIONAL CASH REGISTER COMPANY, DAYTON, OHIO

TUB, SHOWER AND NEEDLE BATHS, WESTON ELECTRIC INSTRUMENT CO., NEWARK, N. J.

whether any particular man keeps time. The foreman's time is recorded the same way, and in more than a few shops the superintendent's time is also taken. When there comes a slack time, and some men have to stand off, these cards play a somewhat important part. They show up the regular man, the one who can be depended on to keep time, and as they can always tell if the man is up to his work, there is no need to think twice which man will be put off. This may perhaps appear hard to some, but I must confess that I quite agree with it; in many cases men are helped by it, and if a man is paid by the hour, it is fair to be straight about it.

Compare with this system the practice of some of the works in England, employing perhaps three thousand men, all entering by the same gate, and recording their time by putting metal checks in a box. Many of them come in at the last moment, put in their checks, then commence a quiet stroll through the works to their appointed place, and after this get off their coats and put on their overall jackets. This will easily mean 5 minutes, and perhaps some of our readers will take an average for this lost time and see what it amounts to, then compare the loss in production, put the two together for a year's work and total up the amount. Ask yourself whether we can afford to do this. For myself (and I have seen and used both the check and recorder), I say it is bad for both master and man, it creates wrong impression with elder men, and with the younger hands it produces an utter disregard of the value of time and punctuality.

I should like to call attention to the meal time as I found it, for, indirectly, this, too, has a bearing on the machine shop. Many of the men go to a private house for meals, much the same as one finds in the

LAVATORY, THE WESTINGHOUSE MACHINE CO., TRAFFORD CITY, PA.

LOCKERS AND DRYING ROOM FOR MINERS' CLOTHES, THE CLEVELAND CLIFFS IRON CO., ISHPEMING, MICH.

works around Manchester, but what a difference in the table. A room set apart for dining and nothing else, two tables with a snow-white cloth, and on each table two large glass bowls filled with various kinds of fruits. The cutlery, of a plated kind, is in keeping with the cloth, while the glasses shone as do the jugs containing ice water. At each man's place is table napkin drawn through a white bone ring with a number on it; a young woman waits on the table and the dinner, I think you will agree, is fair. Two kinds of meat, or fish and meat, such vegetables as are in season, two kinds of sweet puddings and fruit; coffee extra. Beer and malt liquors are absent entirely, and here, let me say, that the American workman is by far the most sober man I have ever met. This meal can be taken as a good, fair standard.

I lodged at the house for one year, and my three meals a day were always of the same good standing. The cost of this meal for six days per week, to those who only come to dinner, was 17 cents per day. My total cost for board and lodging was $5 per week, and it is very much an open question whether it could be beaten in England at the same price. The company at dinner was fairly representative. It included the chief draughtsman, with two assistants, the timekeepers, clerk from the office, four foremen and about ten machinists and machine operators, and with these there was good fellowship all round which had a very distinct bearing on the general method of the works. I have met men at meals in the neighbourhood of Lambeth, Leeds, Openshaw, Salford, and other places, men who were skilful at their trade, men of grit and perseverance, men who would beat any tough job, but I have never seen them meet under such good condition as the American men.

RESTAURANT FOR EMPLOYEES, GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

A standard of good fellowship in

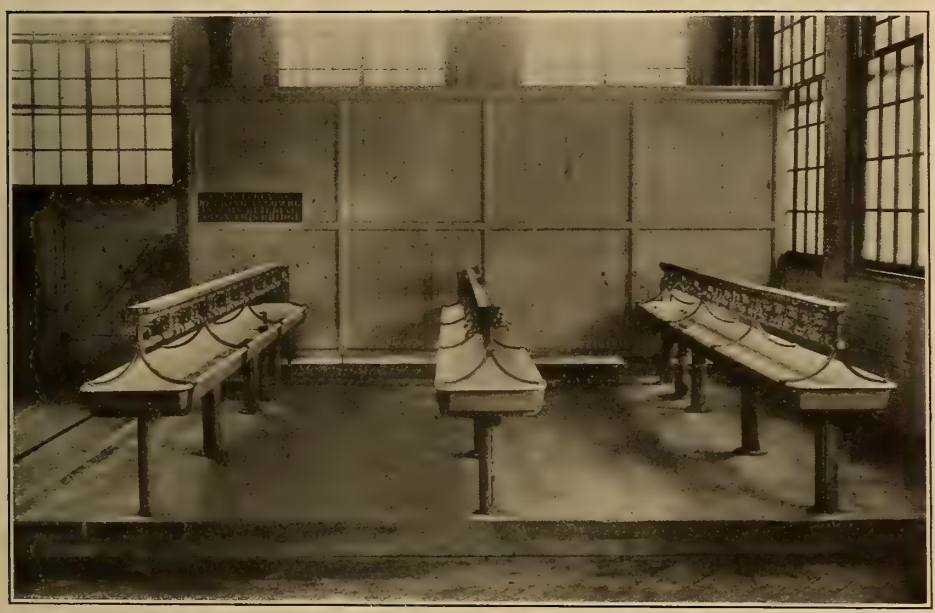
LUNCH ROOM FOR EMPLOYEES, BETHLEHEM STEEL CO.. SOUTH BETHLEHEM, PA.

ANOTHER VIEW OF THE LUNCH ROOM FOR EMPLOYEES, BETHLEHEM STEEL CO., SOUTH BETHLEHEM, PA

DINING ROOM FOR FOREMEN AND ASSISTANT FOREMEN, GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y

WASH ROOM AT THE BROWN HOISTING MACHINERY CO., CLEVELAND, OHIO

an engineering works is an item which should not be lost sight of. It helps along a whole lot of little things, which, if left, soon grow into big, real troubles. I found the American, after a time, a really nice chap. They are exceedingly quick to catch on to new things, they keep each other informed on what is new and useful, and many a time have I seen them help a man in difficulties and machine operator. Many Americans claim that it is a necessity for a draughtsman to first work in the shop, and they will not employ them unless they have done so. Consider for a moment the number of shops that build machines in large quantities, on the interchangeable principle. Consider, too, the thousands of jigs which are used for these. How would it be possible to design these



WASH ROOM, BETHLEHEM STEEL CO., SOUTH BETHLEHEM, PA.

with a job. When it comes to little things, shop kinks and so on, the American is full up. That they hand them around for the benefit of the rest is perfectly plain to any one who will take the trouble to read the *American Machinist*. Undoubtedly the American gets about the works more freely than many of the English men. It has often seemed to me that there is a gulf which cannot be successfully bridged between the shop man and the draughtsman in England, except to a limited few. I did not find this in the States; on the contrary, most of the draughtsmen had been first apprenticed and served their time, and this, no doubt, made them more attentive to the machinist if the men who do it had not had machine-work experience? In many cases a piece of work is enclosed in a jig, which represents a cast-iron box, with feet on every corner, and is such that all kinds of drilling and boring can be done on every side without removing it. You can turn it about, but it is always on some of its feet, you can see underneath it, you can get the chips away, you can bring your drill through and not make a hole in the drilling machine table, you can get a light all round the work, and last, but not least, you can blow out all the dust and dirt with the compressed air pipe and examine the work properly before it is taken out of the jig. There is one

LAVATORY AND SHOWER BATHS OF THE CLEVELAND CLIFFS IRON CO., ISHPEMING, MICHIGAN

EMERGENCY HOSPITAL, J. H. WILLIAMS & CO., BROOKLYN

thing which I think most of us will agree to in American machines, that is they are very ingenious, and well adapted for ease of manipulation. This point is such a time-saver that it outweighs other considerations, such as softer iron, and lightness. These ingenious movements, I think, can be traced to two things. The first is probably due to a want of skilled labour a few years back; secondly, to the exchange of ideas between the designer and the operator of the machine. The first case was undoubtedly the cause of the automatic machine being built, while the second goes on as a matter of course, and to-day one sees the American draughtsmen frequently watching a machine at work, and at the same time taking notes of the operator's movements, with a view to further improvements.

In the drawing office there is always a watchful eye, keeping a lookout for things which are so designed that they cannot be produced on standard tools, and which, if they were allowed to pass, would add considerably to the cost of the machine. For instance, a firm with a good plant of up-to-date tools make a certain machine. They do not let the draughtsman go on and finish his designs and then find out that they cannot do the machine work, he will be promptly stopped, and even then as the machine progresses he will be called upon to explain how certain parts can be machined, and may be asked to design the jig for doing it. This, I think, will explain why the draughtsman is so much in touch with the machinist, and also the value of good-fellowship. The suggestion box also comes into force on this point, and nearly every shop has a suggestion box. I have seen many and I believe much good can be done that way. The following is a copy of the notice over a box at one shop where I was at work:—

The company realizes that workmen who are engaged from time to time on the same class of work become expert and efficient on the same, and, if an opportunity was given to them, that many valuable suggestions would be presented

SUGGESTION BOX, NERNST LAMP COMPANY, PITTSBURGH, PA.

to the company, and we have decided upon a method which, if carried out in the proper spirit will be profitable both to the company and the workmen. We have placed a box in the works, into which the men will deposit in an envelope a description in writing, and, if convenient, a sketch of suggestions and changes that they wish to submit, signing their names to the same. These envelopes will be taken from the box every Monday and the contents discussed at the managers and foreman's meetings on Monday evening. If the suggestion, after discussion, is decided to be worthy of a trial, and does not interfere with some change which we had previously in mind, the tools will be made and the suggested changes put into operation. If the change proves profitable we will, after deducting the cost of the tools and changes, pay to the workman who has made the suggestion, one half of the amount saved for the first twelve months, after it has been put into practice. Make any suggestions, no matter how trifling it may seem to you, and it will be cheerfully considered by us, and if your first idea does not meet with our approval, try again; it is a careful consideration of the little things that make a success of the whole.

These notices are by no means uncommon and I have known men, personally, who have made good sums of money through the suggestion box, sums which have gone into four figures in dollars.

When starting to work in the shops a new man will have given him a number of round metal tool checks with his number on, four checks of a different shape with his number on for drawings, and the key of his drawer; all these are on a ring. First, take the tools, everything that the

THE SUGGESTION BOX AT THE WORKS OF THE NATIONAL CASH REGISTER CO., DAYTON, OHIO

man wants he gets from the tool room, whether it be a jig, a drill, a pneumatic hammer, or a milling cutter, they are all taken from the tool room, and immediately where they are kept is a small hook. When a workman takes a tool he deposits a check, which is placed on the hook where the tool is kept, and he is held responsible for the tool. If it is broken, or by any means lost, he must get an order from the head of the department which he will have to take to the tool-room foreman who will release his check and file up the order. By doing this it is possible to keep track of all tools. It sometimes happens that a particular tool is out when asked for; the man in the tool room has a list of each department with the name and number of the workmen, and he can tell at a glance where it is in use. For instance, suppose A is using a certain tool, and B comes to the tool room and asks for it, and he finds A has got his check on it, he will at once go to A and if he has finished with it he asks for the tool. B then returns to the tool room and puts his check on the hook, and at the same time takes A's check back to him, and A, in his turn, hands B the tool. The same thing applies to drawings. The man in charge of them has a list of every part of the machine built; opposite the name is a number and letter for reference and shop number. You ask for the drawing of such a machine, giving number and letter, and it is at once found, and a check is taken in exchange exactly the same as in the case of the tools. Suppose, now, that we have got the drawing, and the work to be done is milling, on one corner of the drawing you will find what cutters you have to use, and what room they are in. In short, when you get the drawing there is nothing else to do but go on with the work, so correctly do the detailed drawings explain things that there is hardly any excuse for waiting.

(To be concluded)

SOME RECENT DEVELOPMENTS IN MACHINE TOOLS

By Joseph Horner

SEVERAL improvements of importance have been taking place in the department of machine tool design during the last year or two, and a review of some of the later machines of leading manufacturers will indicate the lines along which the developments are being made.

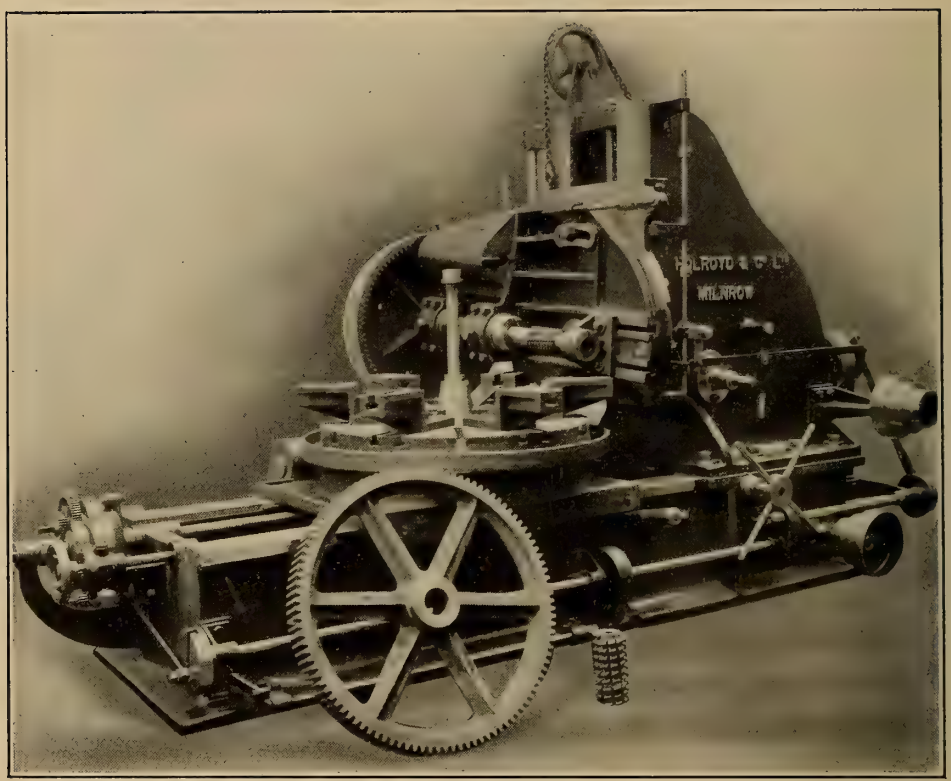
These lines include gear-cutting machines, high-speed lathes, grinding machines, and special tools designed for performing one operation only; besides which, many of the older standardized types have been improved in various details, and which, if small, taken individually, yet when combined they render the machines to which they are applied more efficient, or more precise in operation.

As some eight or ten years ago the cycle boom gave a great impetus to the specialization of certain machine tools, notably turret lathes, so the influence of the motor-car industry is now in evidence. Gear wheels and cams are used in large quantities, and the machines for producing these accurately and automatically are attracting attention. We shall study these better by classifying them in groups.

GEAR CUTTING AND ALLIED MACHINES

The chief interest in these lies in the new machines for cutting spur gears by a system of hobbing. There are three of these of new design, one German, by Schuchardt & Schutte, another of English manufacture, by John Holroyd & Co., Ltd., but built on nearly identical lines, and a German machine of a different type, the Biernatzki. There is also an older one by Reinecker, which, though bearing but slight external resemblance to the others, embodies the essential principle of hobbing spur gears. The idea is one that must have been derived naturally from that of hobbing worm wheels, and such being the case, it is rather singular that its development has come so late. Into the full details we cannot enter, but the underlying principles are as follows:—

The cutter or hob is a worm thread of very low angle, the spiral form being necessary to enable the cutter to operate as a hob. But since the hob is a spiral, and the wheel to be cut a spur, the axis of the cutter has to be set at an angle corresponding with the thread angle. Thus, if the cutter thread has an angle of 3 degrees, the axis of the hob must be set "out of square" by 3 degrees to enable it to produce spur, or square teeth. Moreover, in order to maintain the correct relations of the hob and wheel blank, the latter must be rotated in exact unison with the hob. This is clear, because, supposing it did not do so, then a worm wheel must be produced. Hence, for every revolution of the worm, which, of course, passes through a distance equal to the pitch, the wheel blank must rotate through an arc equal to the pitch. In other words, the cutter must make as many revolutions during one revolution of the wheel blank as teeth have to be cut upon the blank. That is the principle of the machine around which the details are built. The necessary relations are obtained by a set of change gears. It follows that the wheel



GEAR HOBBING MACHINE. J. HOLROYD & CO., MILNROW

blank must make many revolutions before the teeth can be cut through, and that the cutter and blank must be set at correct centers at first, the feed taking place in the direction of the tooth face. In the first few revolutions the full depth of teeth is cut into right around one side, and so it is gradually deepened until the cutter clears itself through on the other side.

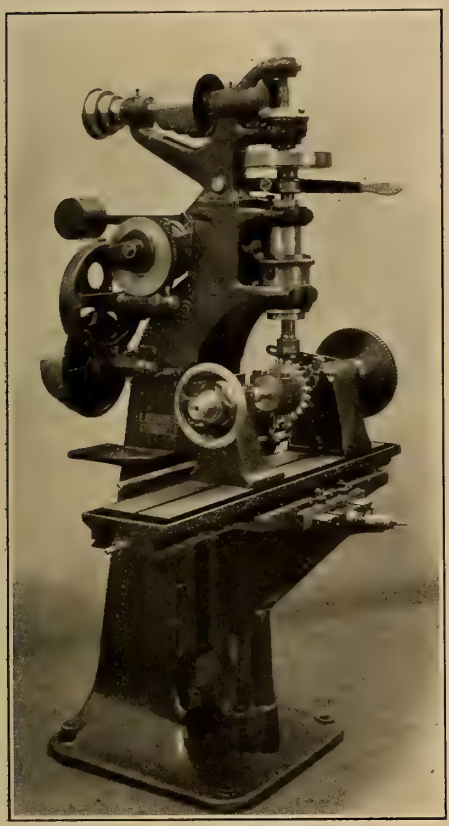
These machines are made in two types: the plain, and universal, the first named dealing with spurs only, and worms, the second, including spiral gears. There is really very little difference between the two, the principle being that the head must have a large amount of swivel movement for spirals. In a plain machine a swivel of 10 degrees on each side of the horizontal covers the angles of all the cutters used, in one for spirals it must swivel to 45 degrees on each side.

The difference in hobbing worm gears is first that the axis of the cutter is set at right angles with the axis of the worm wheel. The angle of the cutter is then reproduced in the wheel. Secondly, the centers of the wheel and hob are not fixed at their final dimensions when the cutting commences, but the wheel is fed towards the cutter as the latter gets deeper into it. Stops set the final or working centers, and when these are tripped the action ceases. The hob, therefore, has no down feed in this case as in spur wheels.

The cutting of spiral gears, as already stated, involves setting the hob to the angle of the wheel, plus the angle of the hob thread. But here the cutter must be given an extra turn, or a turn less, per revolution of the spiral, according to the handing of the spiral, than are necessary for cutting the teeth of a spur wheel in order to produce the spiral form.

This is done by a special set of corrective change gears operating through differential wheels. If this were not done the cutter would not produce a spiral.

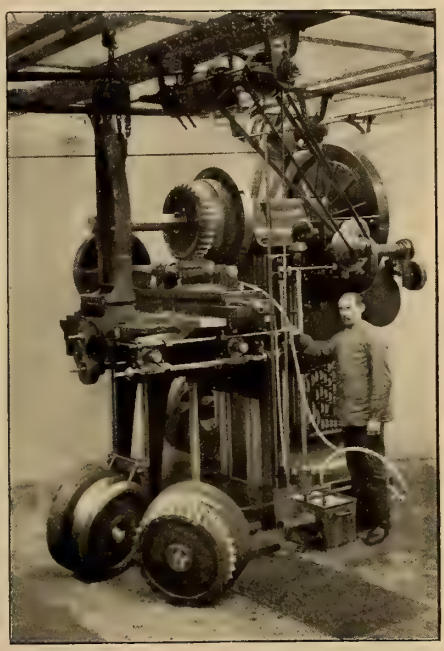
It is impossible to describe in detail the construction of these machines, the illustrations reveal most of them, and those points which are not evident will be generally understood by practical men. The machines are fully automatic, provided



REINECKER TOOTH ROUNDING MACHINE

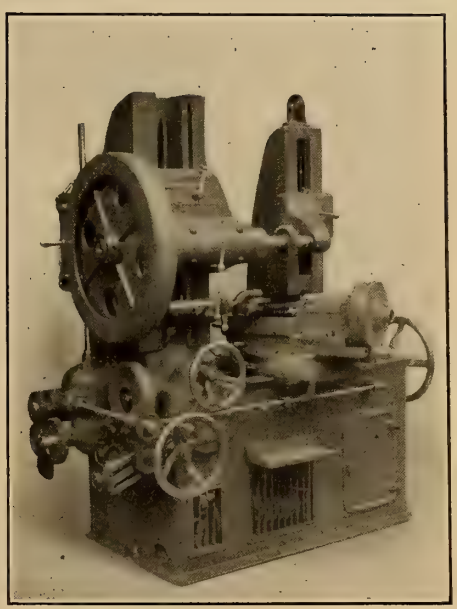
with dividing worm wheel, sets of change gears, feeds, stops, trips, besides hand adjustments. it will be of more interest to consider the points in favour of this method of producing gears.

The ordinary circular-formed cutter does not produce true gears, because it is a compromise. In the involute system, eight standard cutters are made to do duty for all wheels of a given pitch. Such gears are not

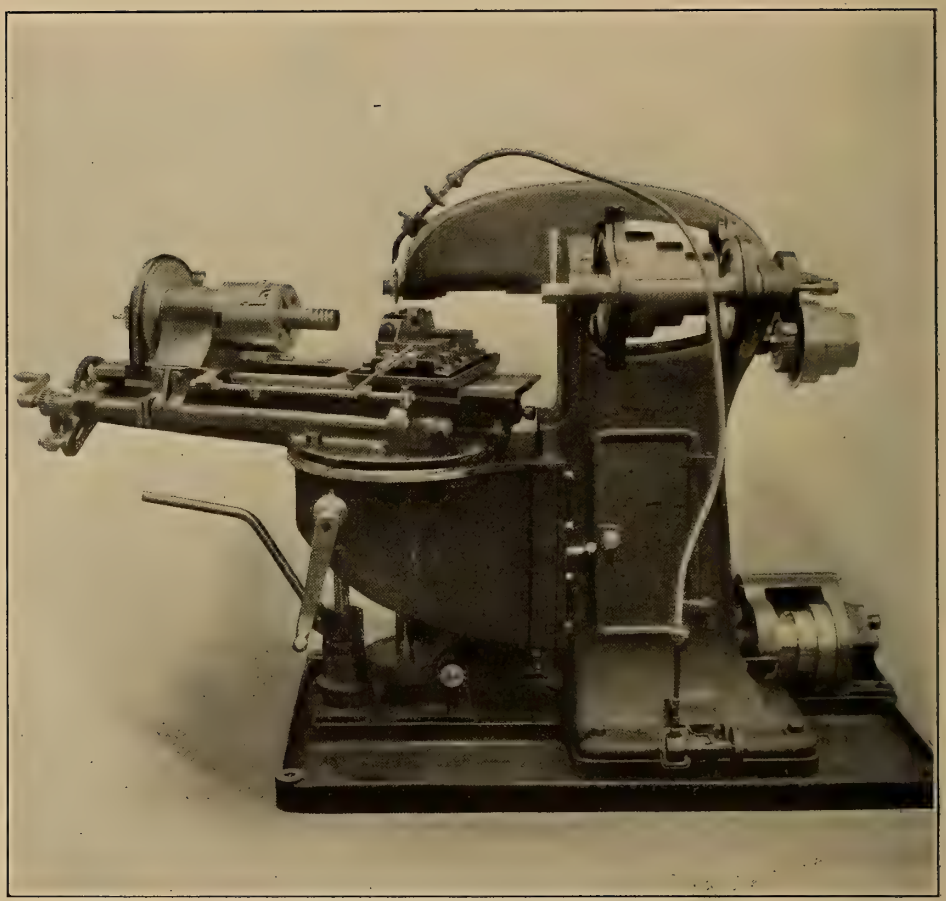


WORM WHEEL HOBBING MACHINE. J. E. REINECKER

bad, but they are not perfect enough for the most exacting demands.



BIERNATZKI GEAR CUTTING MACHINE



SCREW THREAD MILLING MACHINE. J. HOLROYD & CO., LTD.

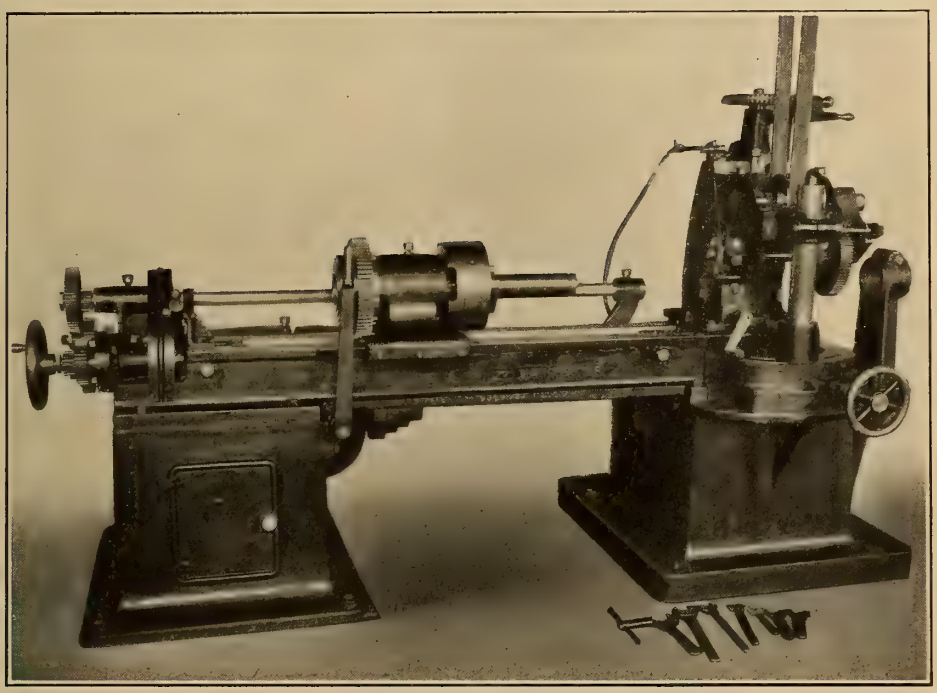
Hence the rivalry of the now numerous generating machines. It is so easy to take the involute rack sections of teeth, and supply it in some way or another to the shaping of the teeth of all other gears, from small pinions to large wheels, that it is done in numerous designs of machine. But the generating machines just noticed, which effect the same results by hobbing, should possess advantages over the action of a single cutter, or a single-face tool of any kind, because the action is divided between the sections of a long spiral, essentially multiple cutters,—by which, wear is delayed and mutual correction ensured. I think another advantage is, though nothing seems to have been made of it, that there is no reason why cycloidal teeth should not be generated by hobbing, which cannot be done in any other type of generating machine.

There are some minor advantages, one of which is that there is no shock of reversing motions, no lost strokes, no indexing and less local heating and distortion. Actually these machines have given some remarkable records of rapid work. To the general objection to a special machine there is the fact that these hobbing machines can be used for ordinary circular cutters, substituting a dividing apparatus with hand pitching. This, however, is of further advantage because ratchets, sprockets, and special teeth forms can be made.

The gear tooth rounder is a new ma-

chine designed to fill a want in motor change gears. Trimming these with chisel and file, as was formerly done, is out of the question now. Two machines have been designed to do just this work alone. The essential elements are a concave milling cutter, corresponding with the tooth profile, an arbor between centers carrying the gears, and having dividing apparatus for pitching, corresponding with the number of teeth; and a cam device for coercing the movements of the rounding tool. Messrs. Pfeil & Co. construct a tooth rounding machine with a capacity up to teeth of $\frac{1}{8}$ inch circular pitch. The modul and circular pitches are marked on the spindle body. The pitching in this is by notched division plates. When in operation the spindle rises and the dividing gear comes into action. The spindle descends and cuts one side of the tooth, when the pitching is repeated. All the teeth on one side are cut in this way first, and then all on the other side similarly. The tooth rounder machine built by Messrs. Schuchardt & Schutt operates in a different way, the cutter going around each tooth point at one time under the control of a heart cam, besides which a dividing wheel is used for the pitching.

An automatic bevel gear planer by the Oerlikon Company (Zurich) is shown by Burton, Griffiths & Co. Some of the Oerlikon machines have been already illustrated in CASSIER'S MAGAZINE. The gear blank is carried on an arbor to which the necessary adjustments are given underneath a reciprocating planer tool. The bevel corresponding with the section of the wheel is imparted by quadrant movements. The shapes of the flank are given by a former which is made to impart the tooth shape. The blank is always well in sight, the tool has quick return, adjustable stroke, five changes of speed, and variable feed for different materials.



SCREW THREAD MILLING MACHINE. J HOLROYD & CO., LTD.

The screw milling machines have some features in common with spiral gear cutters. The Holroyd screw milling machine for long threads has been already described in CASSIER'S MAGAZINE. A modified type of this machine is designed for milling worms and short screw threads up to 14½ inches long. In general appearance it resembles the common pillar and knee type of milling machine. The box body carries a back geared headstock, with overhanging arm, work spindle, and mandrel. The knee, which is of larger dimensions than that of the ordinary milling machine, has a circular face to carry a long swivel slide, adjustable round an angle of 180 degrees. The slide carries the work head, to which suitable movements are transmitted through gears and change wheels for different spirals. Provision is made for chucked work, and work between centers; for quick withdrawal, and variable speeds and feeds, the details of which need not be enumerated.

CAM MILLING MACHINES

Cams are used extensively in motor car work, and in machine tools and mechanism, and gas engines. Rapidity of execution and a high degree of accuracy are both essential, hence filing and hand grinding are being put aside as unsuitable methods. Several interesting machines have been designed for cutting cams alone, and so arranged that several may be produced without the trouble of changing the models or forms.

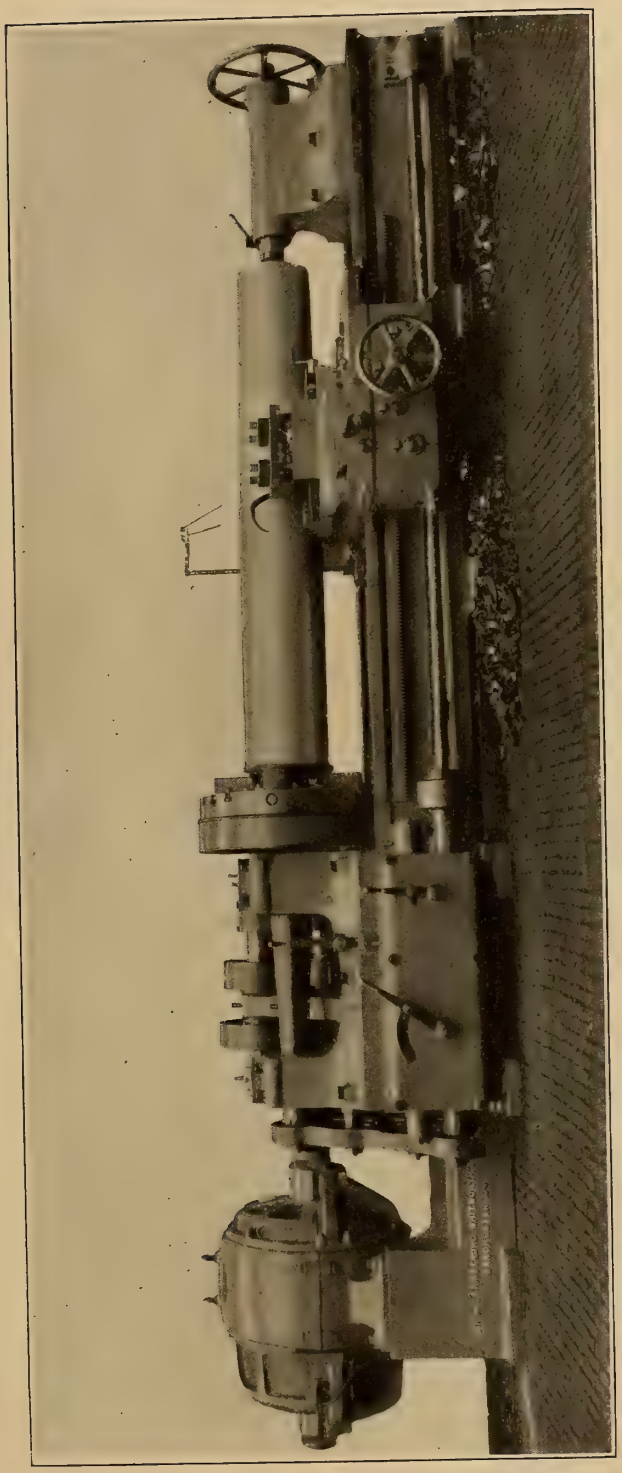
A cam milling machine by Messrs. Schuchardt & Schutte is a remarkably rigid tool. The cam shaft, prepared in the usual way by turning collars on it, is held in a sleeve that passes through the main spindle of the headstock, and is gripped in a self-centering three-jaw chuck, which holds the shaft rigidly close to the cam that is being milled, and which is released when the shaft has to be moved longitudinally for the next cam. The shaft is further steadied in a bracket which occupies the position of a loose headstock. The formers are carried on the main spindle, encircling it, and a roller in contact therewith controls the movement of the cutter head slides. Six cam formers can be mounted side by side, and either one be brought into action by moving the roller into contact with it. Dividing arrangements are fitted for milling cams in correct relation to each other.

Another cam shaft milling machine, by C. W. Burton, Griffiths & Co., is built on a different design. Here the work shaft and the cam form shaft are arranged parallel with each other, the latter being in the rear. The work shaft makes 15 revolutions per minute. The tools are held in two separate cross-slides, and the roughing tool,—an end mill—removes the bulk of the metal to within about 1-64 inch of its size. Then a circular edge cutter with diagonal teeth in the other slide follows and finishes the cam. If the cams have to be hardened, an emery wheel is put in the finishing head for final correction by grinding. Obviously this machine can be used for the production of formers from any standard cam shape. Steadiness of movement of the cam shaft is insured by mounting a 3-inch bar over the work, bearings for which are provided in the headstock. An adjustable bracket can be slid along this shaft and clamped close to the cam which is being cut.

HIGH-SPEED AND OTHER LATHES, AND TOOL STEELS

Typical high-speed or rapid reduction tools are represented by the lathes of Armstrong, Whitworth, Stirk, the Springfield Company, the Lodge & Shipley Company, and drills by several firms, together with cutters, etc., of various kinds.

With regard to lathes designed especially for high-speed work, an interesting point is the abandonment of stepped cones for the all-geared head. Broad belts and single driving pulleys are conspicuous. Hence heavy cuttings can be removed at



HEAVY LATHE FOR HIGH-SPEED TOOL STEELS; 18-INCH CENTRES, 10 FEET BETWEEN CENTRES, DRIVEN BY 60-HORSE-POWER ELECTRIC MOTOR.
SIR W. G. ARMSTRONG, WHITWORTH & CO., MANCHESTER

high speeds, with a low back gear ratio. It is therefore not necessary to drive at an excessively high speed, as in coned lathes, in order to get the power required. Another feature is the provision for maintaining a constant cutting speed on a large range of diameters.

Messrs. Sir W. G. Armstrong, Whitworth & Co., Ltd., give some striking examples of turning and drilling. Thus on an 18-inch center lathe, driven by a 60 H. P. motor, cutting can be done on Siemens steel at 45 feet per minute, taking a $\frac{3}{4}$ inch cut, with $\frac{1}{4}$-inch feed. This produces chips measuring about $1\frac{1}{4}$ inches wide by $\frac{1}{2}$ inch in thickness to nothing. This lathe is capable of cutting speeds up to 400 feet a minute, and the feeds are from 1-16 inch to $\frac{1}{4}$ inch. There are two rests, at back and front. A drilling machine by the same firm, operating on cast iron 2 inches thick, runs a $\frac{3}{4}$-inch A. W. high-speed twist drill at 640 revolutions per minute through the metal in 6 seconds. Mild steel occupies about 11 seconds, the drill making 340 revolutions per minute. This machine has a spindle 2 inches in diameter, with a downward movement of 9 inches, and is driven from a motor by a link belt with variable speeds of 3 to 1. Four spindle feeds, ranging from 35 to 120 cuts per inch, are provided.

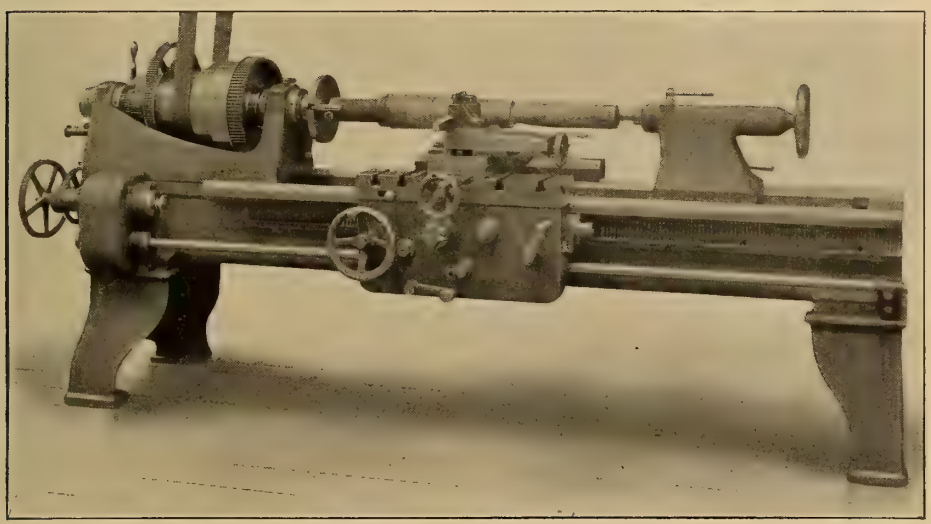
High-speed lathes of very stiff design are built by John Stirk & Sons. One of these is of $8\frac{1}{2}$-inch centers, driven with a $7\frac{1}{2}$ H. P. motor enclosed in the bed, and under the headstock, whence the drive is by chain to the spindle. In this the speed is controlled automatically over a range of diameters between $2\frac{1}{4}$ inches and $6\frac{3}{4}$ inches diameter. The cutting speed is selected and put in by a handle in front, and the speed is maintained on the range of diameters given. The cutting speeds are 50, 75, 100 and 150 feet per minute. In these lathes the headstock, the bed, and the foot beneath the headstock are in one casting.

The Springfield high-speed lathe has a single belt drive and a geared head. The type embodies the nest gears on a disc, 8 gears being attached to the plate, which is of large diameter. Three sets of combination gears also, either of which can be slid over spindles at the left-hand end of the headstock, provide the necessary changes both for screw-cutting and feeding. The feeds are 5 to 1 on the screw, effected through gears. The feed rod comes beneath the guide screw, and below that again is the reversing rod with provision for automatic knock-out. This serves both for feeds and screw-cutting. The guide screw and feed rod cannot be thrown in simultaneously. The screw-cutting ranges from 1 to 26 threads per inch, the feeds from 5 to 140 per inch of traverse. The lathe is of $9\frac{5}{8}$-inch centers, and $19\frac{1}{4}$-inch swing over bed. It has a single 12-inch pulley for a $4\frac{1}{2}$-inch belt. A two-speed countershaft with the gear changes provided in the head permits of twenty spindle speeds. Eight of these are direct belt speeds for finishing cuts. The speeds are so arranged as to give a constant cutting speed for all diameters from $1\frac{1}{8}$ inches to 18 inches. The back gears (with a ratio of 4 and 8 to 1) are arranged in front of the main spindle, the idea being to favor rigidity. Guards, of course, are provided for the gears. The front bearing of the spindle is large, $3\frac{3}{4}$ inches diameter by 7 inches long, the back is $2\frac{3}{4}$ inches by $5\frac{1}{4}$ inches, and a 1 9-16 inch hole goes through the spindle.

The Lodge & Shipley lathe of 9-inch centers is driven by a $4\frac{1}{2}$-inch double belt on a 10-inch pulley. The spindle is relieved of the strain of the pull of the pulley, the latter being taken in sleeve bearings. The drive without the back gear takes place through a clutch; when the back gear is in the clutch is out. There are 18 spindle speeds, screws can be cut from 2 to 32 per inch with 40 changes, and feeds range from 5 to 80 revolutions per inch of traverse with 40 changes. The change gears

are of the best design. A curious feature is the fitting of gauge glasses in front of the headstock to indicate the level of the oil in the bearings reservoir.

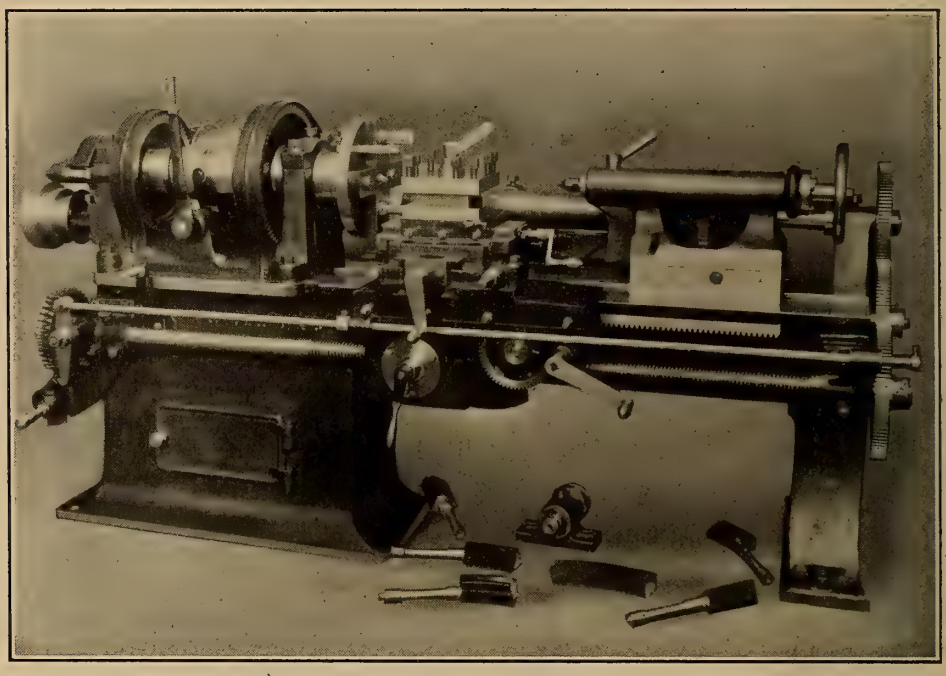
A lathe by De Fries & Co., using tools of high-speed steel, has a segmental nut substituted for the feed screw. The nut has in section a concave thread, forming a portion of a circle of large diameter. It is fastened to the front of the lathe bed. A worm engages with it, driven from the feed rod beneath. The latter and the screw-cutting arrangement are



SCREW-CUTTING LATHE BY MESSRS. DE FRIES & CO., LTD., DUSSELDORF. THIS LATHE HAS A SEGMENTAL NUT ATTACHED TO THE FRONT FACE OF THE BED INSTEAD OF THE USUAL LEAD SCREW

therefore permanently connected in a ratio of 3 to 1 at the gear box next the change wheels. The advantages of the segmental nut are absence of distortion, no irregular expansion between the guide screw and bed, protection from falling chips and dirt, and practically alignment of stress between the nut and the work being cut.

An example of high specialization of interest to steel works, testing bodies, and colleges is a machine designed solely for turning test pieces by means of a scroll form, in place of ordinary form tools, or of turning done without any such aids. The essential feature in the form is that the pressure of cutting is always normal to the axis of the work being produced, instead of coming on laterally. Two operations are provided for, a heavy, roughing sliding cut with the cross-slide locked, the other a forming cut. The design might be described generally as that of a common lathe with the scroll form shaft added at the back. The movements of the forming slide on the lathe carriage is controlled by the scroll behind, the section of which is simply that of the test piece, cut at an inclination (the scroll) along the shaft. A roller in contact with this follows the scroll, and the cutting tool must follow the same outlines. Very heavy cutting is practicable, because the harder the pressure of the cut the more tightly is the roller pressed against the form. The longitudinal travel is controlled as follows:—The pitch of the scroll is always the same as that of the lead or feed screw in front of the machine, and the two together are geared together with equal wheels. The feed screw is worm-driven, giving ample power. Two sets of speed gearing provide for roughing and finishing cuts, the lat-



MACHINE FOR FORMING TEST PIECES. J. HOLROYD & CO., LTD.

ter being double the speed of the former. Three changes of feed are obtained by three-stopped cones and the feed can be disengaged automatically at any point by tripping a drop-worm box. A square turret holds four tools. Obviously the scroll forms can be turned from existing test pieces which have to be reproduced in large quantities. A milling cutter is substituted for the roller, and a blunt tool is set against the test piece. This machine is by John Holroyd & Co., Ltd.

Another class of machine designed for performing one operation only is the De Fries crankshaft lathe. Essentially it comprises two chucking heads, driven by spur gears from a back shaft. The heads each carry chucking plates, which combine circular and lateral adjustments, by which means the throws and angles of the cranks are obtained without direct measurement, the setting being accomplished by graduations on the plates. Besides this, there is a steady bracket having a revolving ring, also spur-gear driven from the back shaft. The ring is fitted with adjustable clamping dogs which grip the opposite sides of the web of a crank close to the place where cutting is being done. Thus, the crankshaft can neither bend, nor be subjected to torsional stress, and heavier cuts can be taken than as though the work were unsupported.

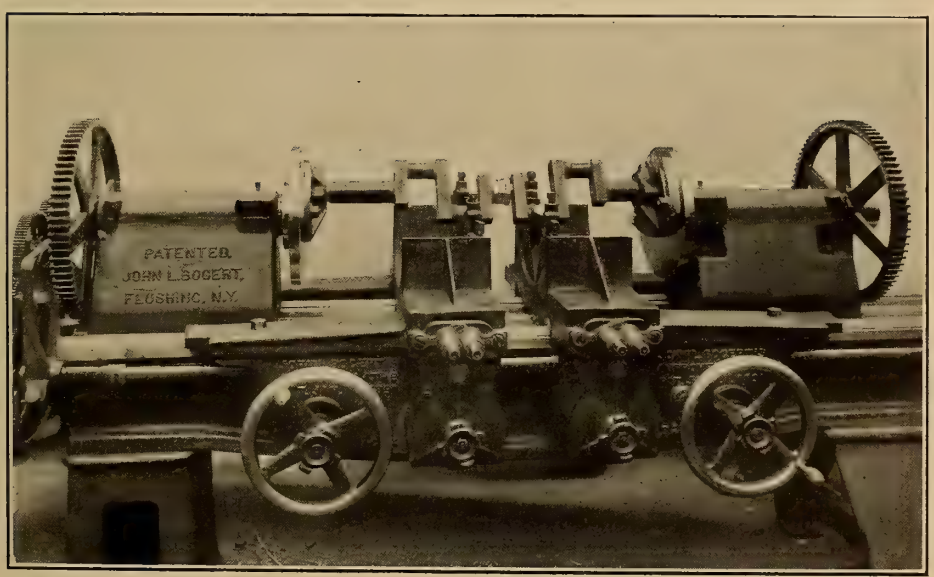
The Bogert crankshaft lathe is an ingenious tool, this machine being handled in England by Schuchardt & Schutte. It is used for the smaller shafts, such as for automobile work. There are two heads, both of which serve as drivers, the spindle of each being rotated by spur wheels, actuated from pinions on a shaft located between the bed shears. Instead of supporting the crankshaft on point centers, special clamps are attached to the face plates by which the ends of the shaft are firmly gripped. These clamps are pinned to the plates at one point, and may be swivelled by means of curved slots to suit the throw of the crank to be turned.

The two carriages which run on the bed by long gibbed slides are fed along in either direction automatically by change gears, splined shaft, and gears connecting to a rack on the front of the bed, or they are moved by the hand wheels seen at the front. The slide rests, which constitute a striking feature of the design, are duplex, having tool rests at front and back, each being moved independently by its own screw; the ends of these are seen in the photo at the front. By this method of having tools in operation on each side of a crankpin, the stresses so balance each other that the usual steady rest is unnecessary. The rests are of plated form, as seen, to afford rigidity to the slides, which have to be narrow to pass between the crank webs.

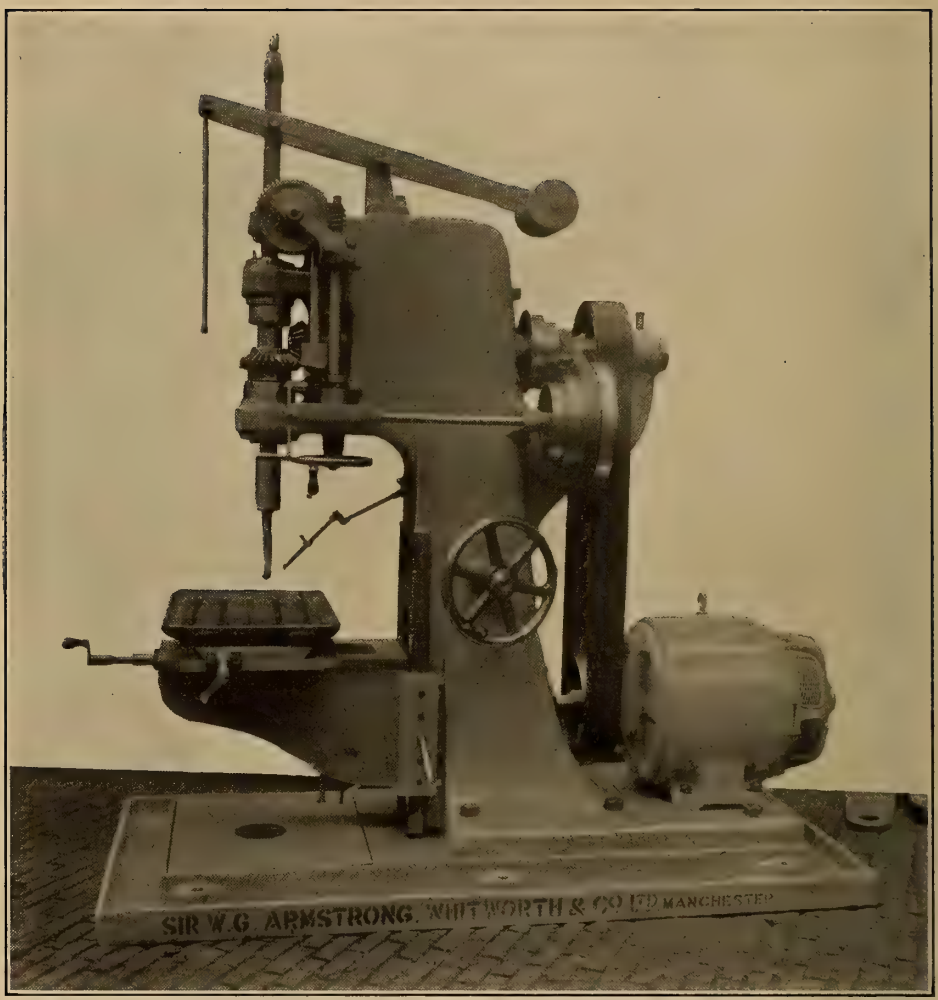
Among the high-speed tool steels may be mentioned the A. W. (Armstrong, Whitworth) brand, the Novo, of Jonas & Colver, Ltd., the 0172 of Cammell, Laird & Co., Ltd., as well as Mushet and other brands by Samuel Osborn & Co., Ltd.

Novo high-speed steel is hardened when at a bright yellow heat, only just short of a white welding heat, an air blast being used. An exception is made in the case of milling cutters, drills, taps, cutting dies, etc., which may be hardened in oil to prevent the formation of heavy scale on the edges. Punches are raised to a white heat and hardened in oil. The temper is then drawn to a blue heat.

A few records of Novo steel performances will serve to indicate the remarkable difference between it and ordinary carbon steels. There are two advantages, the second of which is sometimes overlooked,—the steel will operate at a higher rate, and it will endure longer without regrinding. This latter point means a good deal in the saving of time, and keeping dimensions on repetition work. Punches show interesting records. A $\frac{3}{4}$-inch punch made 56,000 holes through structural steel $\frac{3}{4}$-inch thick, against 5,600 holes by a carbon steel punch. On very hard 1-inch nickel steel armour plates, from 800 to 2,000 holes are punched, against from 6 to 20 holes with carbon steel. One-inch steel nuts are punched out cold, the tool running from 20 to 25 hours without requiring redressing; ordinary punches only last 3 to 4 hours on such work. A Novo punch produced 60,000 holes in $\frac{5}{8}$-inch to $\frac{7}{8}$-inch



SPECIAL CRANK-SHAFT LATHE. JOHN L. BOGERT, FLUSHING, N. Y.

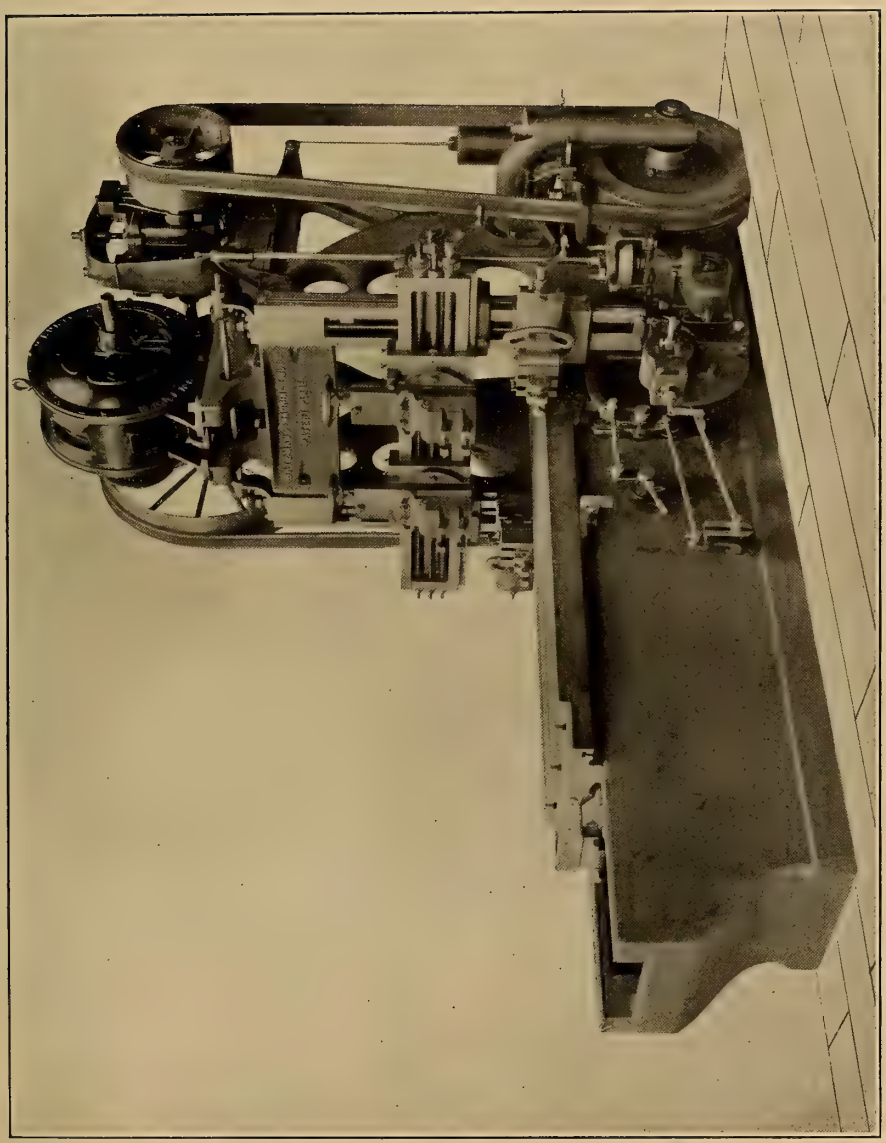


TWO-SPINDLE VERTICAL DRILLING MACHINE FOR USE WITH HIGH-SPEED STEEL. SIR W. G. ARMSTRONG, WHITWORTH & CO., MANCHESTER

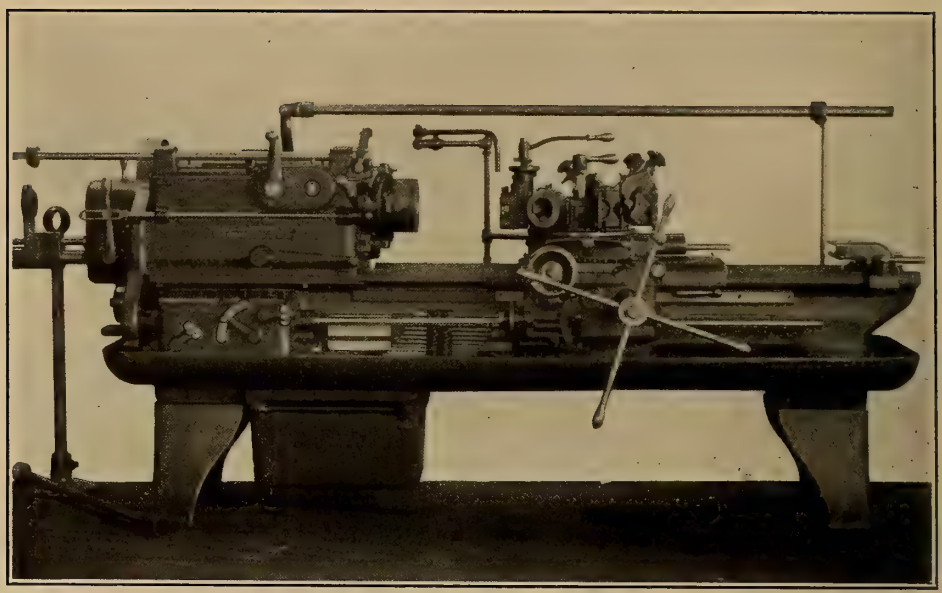
steel plates before redressing became necessary.

Results with milling cutters show that the high speed ones can be run about three times faster and will outlast the ordinary cutters by from twelve to fifteen times. An instance of drilling comparisons with a 1 1-32-inch Novo drill, and a carbon steel drill, showed that the first, running at 128 revolutions per minute, put through 596 holes in $\frac{5}{8}$-inch hard steel castings. The other tool, ran at 80 revolutions, had its point burned off at the sixth hole. Equally striking results are achieved with various other tools.

An interesting development is that of Messrs. Buck & Hickman, Ltd., in the shape of work done by relieved milling cutters of 0172 steel, profiled and built up to suit the sectional shapes of the hubs of motor-car wheels. These, like cycle hubs, have hitherto been produced chiefly by broad forming tools on a cross-slide. By the new method they are done on a horizontal milling machine of Lincoln or other type. The blank, prepared by drop forging, or by casting



IMPROVED PLANING MACHINE WITH MOTOR DRIVE THROUGH CHANGE-SPEED GEAR BOX. CUTTING SPEED, 65 FEET; RETURN, 220 FEET PER MINUTE. BATEMAN'S MACHINE TOOL CO., LTD., LEEDS



OPEN TURRET LATHE WITH CROSS SLIDING TURRET. THE PRATT & WHITNEY CO., HARTFORD, CONN.

is rotated slowly at a rate of $\frac{3}{8}$ inch per minute. The cutter revolves at the ordinary speeds according to the character of the work. It is pointed out that the advantage gained was two-fold. Using a forming tool on a cross-slide, damage to the edges may occur, in which case the tool has to be removed for regrinding and be reset. Damage is less liable to occur to the milling cutter. Also the milling is a more rapid operation. The price given for the hubs is stated to be 1s. 6d. each when formed, and $1\frac{3}{4}$d. each when milled.

HIGH-SPEED PLANING

The high-speed planing machine built by Bateman's Machine Tool Company, Ltd., of a capacity of 30 inches by 30 inches by 8 feet has a cutting speed at the rate of 69 feet a minute, and return at 220 feet, making 10 cycles of cut and return in 1 minute and 41 seconds, using A. W. high-speed tools. One feature which greatly assists in smooth reversal in this machine is that of the table rack, which has a limited movefent longitudinally, and is fitted with adjustable compression springs which absorb the shock of reversal, and help to start the table at the return, so relieving the belts of some strain. Heavy fly-wheel loose pulleys are used at the sides of the bed, which are brought into action alternately. The belts being wider than the fixed pulleys overlap on to the fly-wheels when thrown off. A good deal of the energy of the fly-wheels is thus imparted to the fast pulleys. Further assistance is afforded by means of friction clutches operated by the belt-striking mechanism, these clutches conveying energy stored in the fly-wheel pulleys to the fast pulleys. Variable cutting speeds are obtainable by the use of a change-speed gear box, giving rates of cutting at 20, 40 and 60 feet per minute.

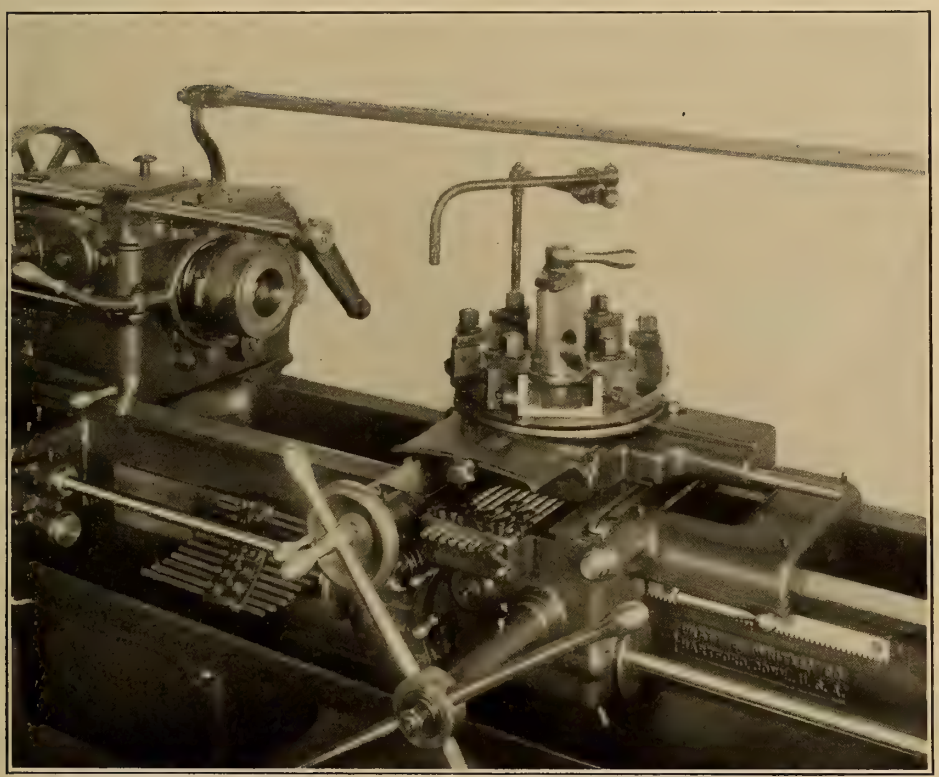
SCREW MACHINES AND TURRET LATHES

Among the redesigned screw machines may be mentioned the Simplex, by C. Churchill & Co., Ltd. The advantages of a four-spindle machine are familiar, the principal one being that four different tools may be operating at once on four different pieces, and the pace is set

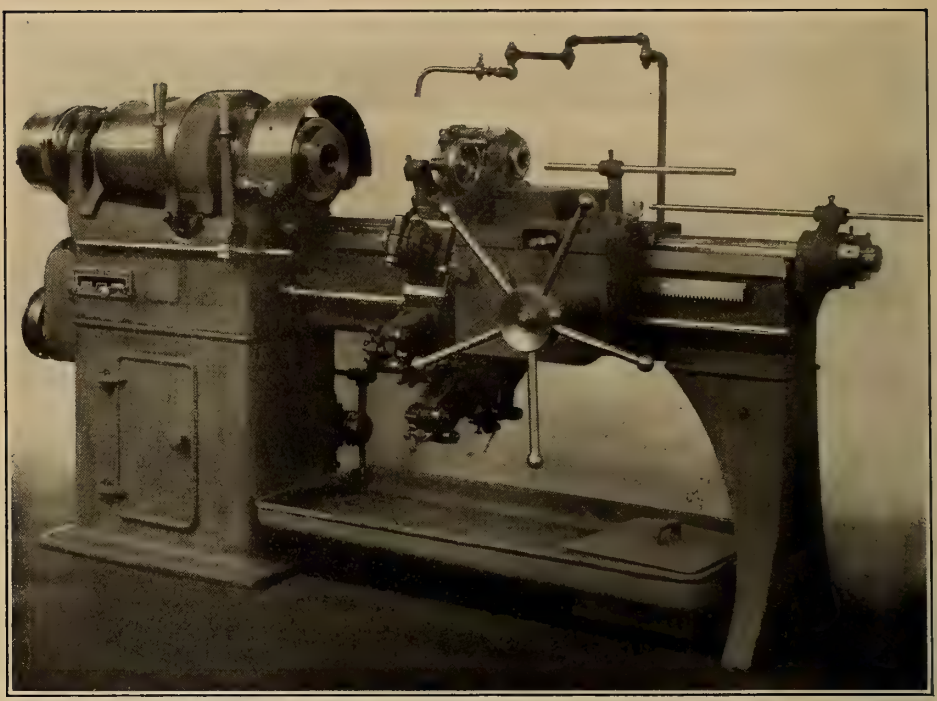
by the time taken on the longest operation. In the Simplex machine the improvements made are in details. Thus, the use of cams to traverse the tool slide is abandoned for a disc, adjustable to various angles on the cam shaft,—a swash-plate,—which engages with the tool slide. The plate is hinged on a globular boss in the cam shaft, and its angle is adjustable by a worm and segmental rack.

Another improvement relates to the cylinder which carries the work spindles. A worm wheel below rotates a ring-worm wheel, or "free wheel," which embraces the cylinder, and which revolves at the same speed as the cam shaft. At each revolution of the latter a sliding pin in a groove at the side of the cylinder engages with a slot in the free wheel, and at the same instant a spring plunger at the bottom being withdrawn, the cylinder is rotated through 90 degrees of arc. The sliding pin is then withdrawn by a fixed cam, and the plunger again engages beneath the cylinder. The worm wheel avoids the upward strain which existed when toothed segments were used.

Tapping and screwing, and the release, or backing-out or off movement are done without reversing or stopping, both actions taking place during advance of the tool slide. It is a patented device. During tapping the tap runs at a higher speed than the work, though revolving in the same direction, the tap being clutch-connected. When the proper depth is reached a stop throws back the clutch, and the spindle is retarded, with the result that the tap (or die) is ran back from the work. There is thus no shock, because there is no stopping and starting, less wear, and greater output.



PRATT & WHITNEY OPEN-TURRET LATHE, SHOWING ARRANGEMENT OF CROSS SLIDING TURRET



THE FOSTER RING-TURRET LATHE

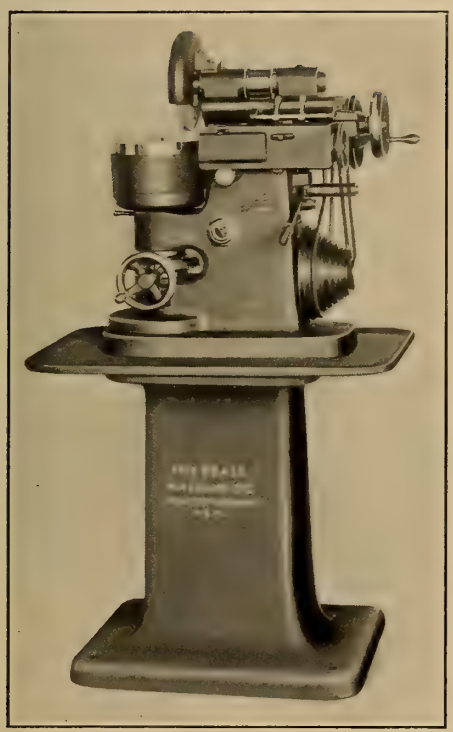
Two adjacent pulleys at the back of the machine are used, one for the feed gears the other for the rapid rotation of the tool spindle cylinder on the termination of a cycle of operations. The belt forks are shifted by cams on the cam shaft. There are a number of other features in connection with the Simplex design, into which it is not possible to enter here.

The Foster ring-turret lathe, handled in Great Britain by C. W. Burton, Griffiths & Co., is an interesting machine. In this the turret is a solid ring encircling the bed, fitting with angular ways, one of which is adjustable for wear. Risk of leverage is thus eliminated. There is also nothing behind the tool in operation. There are eight tool holders in the turret, each of which has its independent feed stop. In operation the turret carriage is run back to clear the tool from the work and the turret rotated by power automatically with an intermittent gear ring. One or more tool holders can be passed. The alignment is secured by a tapered locking pin below the tool in operation, which keys the turret to its ring bearing.

Another turret lathe by G. G. Prentice & Co., also sold by Burton, Griffiths & Co., is designed to tool castings. Five work grippers are carried in a turret rotated on a stiff shaft. It differs thus from most turret lathes in which the tools rotate. There are four tool spindles, in line with four of the work chucks, the fifth one being left free so that the operator may keep the lathe supplied with pieces. When the work is rotated, and as the tools are brought into operation, the turret is held rigidly by a heavy friction block that is moved along the bed and pressed against it. A notched wheel locks the spindles during cutting. A $\frac{3}{4}$-inch globe valve body can be tooled in 15 seconds. The heads and bed are cast in one piece to secure rigidity.

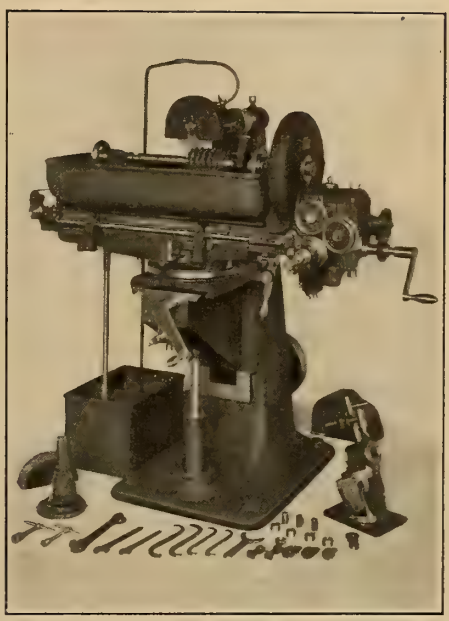
A horizontal cylinder type of Pitt-

ler automatic machine handled by Burton, Griffiths & Co. is perhaps most interesting from the fact of the large number of attachments which can be fitted to it when required. This is in keeping with the Pittler lathes, which are nearly universal machines. The turret carries five tools, either of which can be driven in a wide and regular range of speeds by means of friction discs and

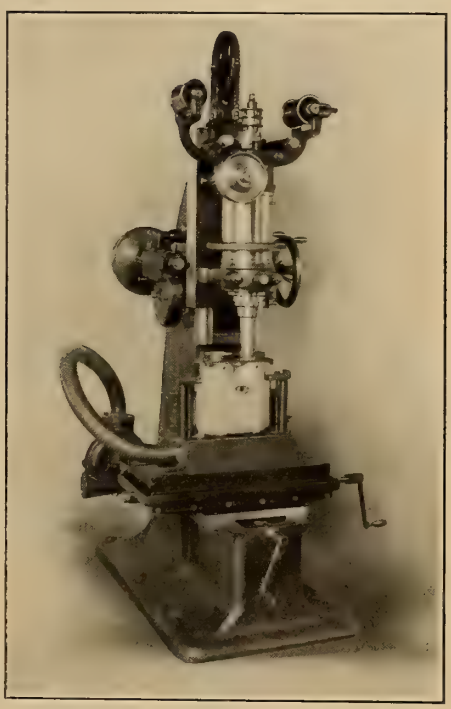


MAGNETIC GRINDER FOR DISCS AND RINGS. HEALD MACHINE CO., WORCESTER, MASS.

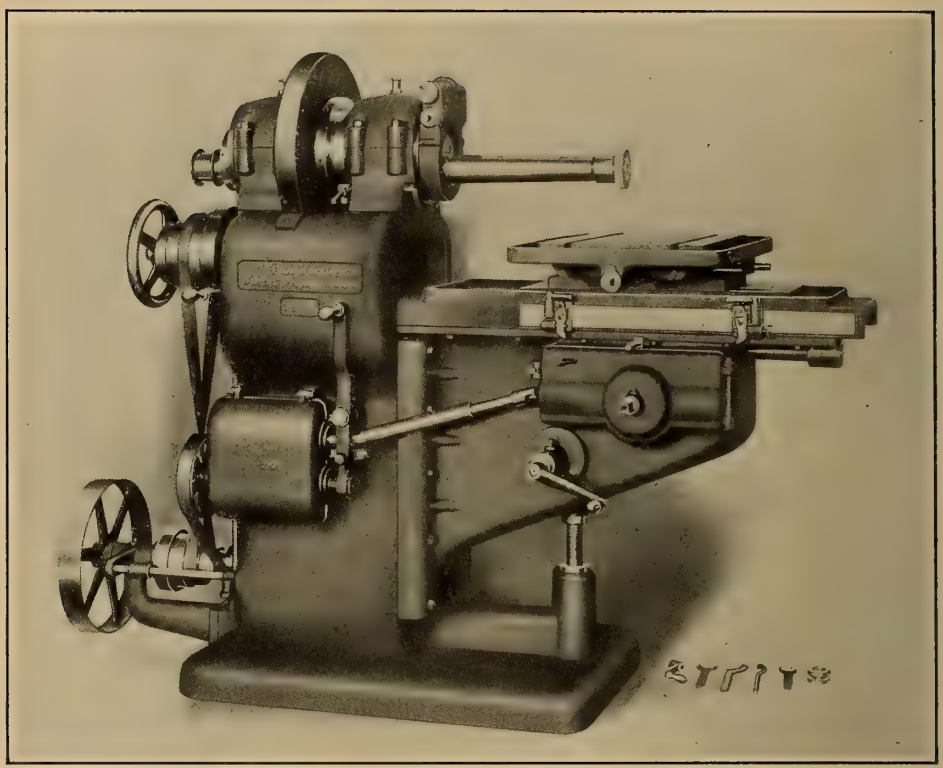
bowl. The cam shaft is behind the lathe instead of below, by which the falling of chips on the shaft is avoided, while the cams are always under observation. The movements of both turret and cam shaft are actuated by a worm and worm wheel, and the worm spindle is also operated rapidly by a coupling for quick return. The feed mechanism can be controlled by a crank when fixing up the tools. The hollow spindle has a self-centering chuck and wire feed. Two ratios



SCHMALTZ CUTTER GRINDING MACHINE



SCHMALTZ VERTICAL CYLINDER GRINDING MACHINE



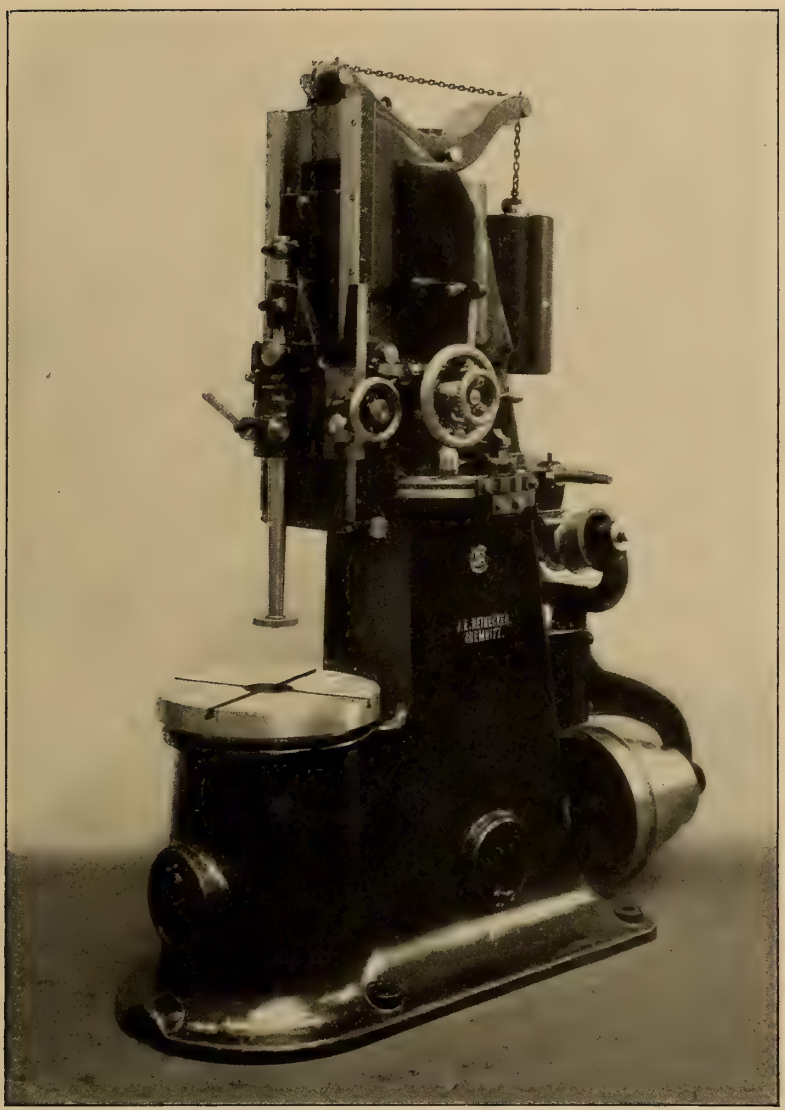
CYLINDER GRINDING MACHINE. THE HEALD MACHINE COMPANY, WORCESTER, MASS.

of back gears control the forward and backward movement of the spindle.

Some of the principal attachments include one for fitting in one of the tool holes in the turret for drilling small holes in work of larger diameter than is possible in a drill held in the turret direct. The same apparatus is used for drilling or milling holes eccentrically to the axis of the chuck spindle. With this also a screw-cutting attachment is used. A fitting put on the cross-slide bores holes around the circumference of circular pieces. There is also an attachment for slotting screw heads, another for turning eccentrically outside, an inside forming and recessing attachment, a taper and profile turning (copying) attachment. There is a magazine fitting and feed for performing second operations on pieces that have been partly done and cut off in the machine. An overhanging cutting-off attachment is fitted when great accuracy is desired which would otherwise have to be done by finishing on another machine. Lastly there is an automatic stop, with a bell which rings, when on the completion of a cycle of operations the machine is made to stop the countershaft.

GRINDING MACHINES

Grinding machines naturally form an active department of machine tool construction. Machines are used for grinding notor and other small cylinders, instead of finish-boring, also for grinding the faces of discs, and rings for cutter grinding, besides ordinary cylindrical work. In finishing the cylinders of motors, the bore is generally roughed out in a boring machine, and the grinder finishes and polishes the surface. The essential mechanism is that of the planet spindle, in which a movement of rotation at a slow speed is imparted to the



VERTICAL-SPINDLE MACHINE FOR GRINDING HOLES UP TO 14 INCHES IN DIAMETER. BUILT BY J. E. REINECKER, CHEMNITZ-GABLENZ, GERMANY

actual grinding spindle, rotating at a high speed. Eccentric mechanism, with provision for fine adjustment, effects this relation. The rest is a matter of detail concerned with the traverse feed, and the movements of the table slides. A vertical spindle machine, by Frederich Schmaltz, is illustrated, also a horizontal machine by the Heald Machine Company.

A new design of cutter grinder by F. Schmaltz is offered by the Agenoria Company, Ltd. This machine grinds the faces of the teeth of formed cutters automatically and on straight or spiral cutters alike. For the latter a spiral and dividing head are fitted. The self-acting advance of the cutter teeth and guide for the spirals is effected so that the cutters

are advanced by one tooth at the completion of each backward and forward, or combined stroke of the table. The machine is fitted for wet grinding, but a dust exhauster for dry grinding can be supplied.

Perhaps the greatest novelty among grinders is that of Burton, Griffiths & Co. for smoothing the square holes of sliding gears for motor cars. A grinding bar carries at one end a small emery wheel rotated by a cord. The work is held in a chuck attached to a dividing head, which can be set to a square, or any other angle. This head, mounted on a carriage, is fed past the grinding wheel with a hand traverse. A cross traverse fitted to the head and having a micrometer screw feeds the work horizontally against the wheel. This is the essential action of the machine, omitting details of its construction.

Magnetic grinders are extremely useful machines for light pieces which cannot be clamped without distortion. The work is rotated by the chuck under the wheel, the edge of which traverses over it, the latter movement being effected by hand. The vertical feed is also by hand, but it may be rendered automatic. The feed for thickness is measured on the edge of a disc divided into 1-1,000 inch or 1-100 millimeter. The chuck drive is effected through bevel gears in the pillar under the table, driven from grooved pulleys with a cord, and having eight grooves for as many different speeds. In a machine which is fitted with automatic traverse to the wheel, a stop arrests the movement of the grinding wheel after one trip across the work and back. There is a friction brake for stopping the chuck. The travelling head is hinged for grinding tapered work, or clearances. Wet or dry grinding can be done, and for the latter a dust exhauster is fitted.

In another way magnetism is utilized in the Dudgeon magnetic work holder by Selig, Sonnenthal & Co. This is of special use in connection with operations on disc grinders, taking pieces of iron and steel too small to be held in the fingers, and which would become heated rapidly. The holder contains four cylindrical permanent magnets coming out against the face of the holder body, which is of aluminium. The work is gripped laterally between movable clamps, and a shoulder below prevents vertical slip. The holder can be set parallel or at an angle in plan. Spare magnets are provided in case of emergency.

(To be concluded)

Current Topics

IN presenting the steel makers' side of the question of rail breakages in our leading article this month, Dr. Bayles calls attention to a most important matter, not only with regard to the improvement of ingots for rail making, but also for structural steel and the products of the steel mill in general. It is but a short time since the presentation before the Iron and Steel Institute by Mr. Gayley of his paper on the use of the dry air blast in the manufacture of pig iron took the world of metallurgy by storm. Some endeavored to prove that the mere removal of the moisture from the blast could not produce such results as were recorded at the Isabella Furnace, but when it was shown that the results could not be disproved the trend of investigation turned toward the discovery of the reasons for the improvement.

Now, we have the proposition to apply the same process to the removal of moisture from the blast supplied to the Bessemer converter, and if results in any way comparable to those secured in the blast furnace are obtained it may be that the Bessemer process can hold its own against the open-hearth furnace as a method of producing rail-steel ingots. Uniformity is undoubtedly one of the important elements in the production of high-grade metal, but it must be uniformity in all of the elements included in the finished product. With a blast of variable moisture-content uniformity in the product cannot be expected, and it is altogether possible that the application of the dry-air blast to the Bessemer converter may be the means of enabling the converter to maintain its place in the competition between the rival processes.

THERE has been more or less talk about the extent to which young college graduates in the United States find ready employment in the large shops and manufacturing establishments almost immediately upon the completion of their college courses, and it is interesting to be able to confirm the correctness of this state of affairs at the present time. In a communication from the professor of mechanical engineering in one of the large technical colleges the following statement will explain itself and form interesting reading for those who are interested in the relation of modern educational methods to practical life. This especial school is but an example of the ex-

perience in other engineering educational institutions, and this particular professor says:

"We will graduate fifty men this year, and a fine crowd of fellows. They are all placed except three or four, who want a special kind of work and will get it. Three of them go to Schenectady, three to Westinghouse Electric, three to the United Gas Improvement Company, two to the Baldwin Locomotive Works, one each to Cramps, Southwark, Ambridge, American Locomotive Works, two to the New York Telephone Company, etc."

No better evidence than the above report could be given as to the extent to which the modern engineering training of the technical school is furnishing men immediately acceptable to employers, and the names of the works which thus take the graduates into their service give additional proof of the acceptability of the college graduate.

AT the Soiree of the Royal Society recently held at Burlington House there was exhibited, among other interesting matters, an invention which, in the opinion of many qualified persons, is destined to mark an epoch in the art and practice of locomotion. We refer, of course, to the Brennan monorail car.

The little six-foot model shown running by Mr. Brennan in his own grounds at Gillingham, consists of a barge-shaped body, with what might be termed an overhanging stern or counter at each end. Beneath these extremities are placed the bogie wheels, two at each end, and all, of course, in the line of the keel, so to speak. One wheel only at each end is driven, its fellow being connected to it by little outside cranks and coupling rods. These bogies are capable of movement, relatively to the carriage above them, not only in a horizontal plane, as usual, but vertically as well, so that a line laid purposely with very sharply recurring up-and-down alternation is taken just as easily as a series of zig-zags would be. The novel feature about the car, and the peculiarity which attracts at once the attention of the observer is the remarkable stability of the apparatus, without any apparent reason why it should not fall over. Whether in motion or at rest, it remains upright, although its base is practically only a line. Try, while the car is at rest, to push it over; it resists not as an inert stone wall would do, but with an active opposition, which actually returns your pressure. Shift all to one side the distributed weights with which the car is loaded and that side defiantly raises itself a trifle higher than before.

Leaving the circular track (only a piece of gas pipe) on which it has been running, the inventor switches it on to what is surely the most intricate and puzzling piece of line ever vehicle was called upon to traverse. It is no more than a piece of steel wire rope laid upon the grass of Mr. Brennan's lawn, in the most fantastic curves, many of them of a radius less than the length of the car. In and out the little car runs, taking the reversed curves with never a mistake, actually leaning over of its own accord alternately to one side or the other as though endowed with intelligence. After this we are not surprised at anything, not even when the car takes an aerial journey over a tight rope of a hundred-foot span, with a guarantee of good faith on board in the shape of an adventurous gentleman of nearly ten stone avoirdupois.

The directing intelligence of the car, its soul, as one might say, is contained in two small fly-wheels, about five inches in diameter, arranged to run at equal speeds in opposite directions, at the rate of about 7,000 revolutions per minute, this motion involving an expenditure of power estimated to amount to about 1 per cent. of the propelling power in a full-sized car.

Granted that the possibilities opened

A SWEDISH RAILWAY MOTOR CAR

up by the successful performance of the model are borne out upon the large scale,—and there is every promise of it,—one may imagine, say, a huge double-decked tram car balanced on a single rail; to all appearance perilously in danger of overturning, yet more secure, by far, than any car of normal gauge.

It may be objected that should the gyrostatic fly-wheels stop, the vehicle would immediately topple over, with disastrous results. This is probably the first idea which occurs to every one who sees the car in motion, but there is really no danger. In a projected full size carriage of forty feet in length the fly-wheels would be a little less than three feet in diameter, running from 2,000 to 3,000 revolutions per minute, in a vacuum. The wheels would be driven by electricity, as a matter of course, and, with a moderate expenditure of power, it would take some time to get up the full speed, while if the motive power were withdrawn it would take a corresponding time before the wheels would cease running. Legs, or props, of course, would be put forth for supporting the vehicle while not in use.

In view of the results already obtained with the Brennan car, we may look forward with confidence to an impending revolution in some methods of land transit.

IN view of the rapid development and extensive introduction of rail motor cars on British railways, the peculiar and unique specimen illustrated herewith will be of interest, especially as it comprises features of design which are not, and, so far as the writer is aware, have not been, employed elsewhere.

The machine was introduced a few years ago particularly for official inspection trips on the Stockholm-Vesteras - Bergslagens Railway, of Sweden, though it is also used occasionally for ordinary passenger travel.

The locomotive has only one cylinder, placed just inside the left-hand frame plate, and working directly on to the cranked leading axle. The steam chest is placed above the cylinder, the slide valve being an ordinary cast-iron valve worked by a radial gear without eccentrics.

The boiler is of the marine return-tube type, and rests on a water tank fitted between the frames. The regulator can be operated either from the front or from behind.

Seats are provided on either side above the driving wheels, but the driver is usually stationed behind, where water tanks, a coal bunker and a tool chest are provided, and where the reversing lever, injectors, whistle and brakes are convenient for manipulation.

The carriage is provided with a

small platform at each end, giving access to the compartment, which is adapted to seat four or five persons. A sofa, arranged lengthwise, a small table, wash-stand, hat-racks, etc., comprise the internal equipment.

The combination is usually timed at about 17 or 18 miles an hour, but in favourable weather speeds of 34 to 37 miles an hour have been frequently reached.

This railway is a standard gauge line with a mileage of 242 miles.

The following are the principal dimensions of this interesting machine:

Cylinder, 3⅞ in. diameter, 6⅞ in. stroke; diameter of driving wheels, 24 in.; diameter of trailing wheels, 15⅓ in.; wheel-base, 60 in.; length of boiler (outside), 32⅛ in.; diameter of boiler (outside), 22¼ in.; grate area, 1⅝ sq. ft.; number of tubes, 26; length of tubes, 26⅓ in.; diameter of tubes, 1⅜ in.; steam pressure, 160 lb.; capacity of coal bunker, 790 lb.; water capacity, 60 gals.; total length of car, 11 ft.; width of car, 6 ft.; height from rail, 7 ft. 8 in.; wheel diameter (car), 17 in.; total wheel-base, engine and car, 15 ft. 6 in.

AT some of its recent meetings the American Society of Mechanical Engineers has carried out the plan of arranging for a general discussion of some special topic, inviting communications in advance, and thus obtaining both written and oral opinions upon the subject in a most useful and interesting manner. An example of such discussion appeared in the manner in which the subject of bearings was treated not long ago, while at the recent convention in Indianapolis the use of the superheated steam was given a similar treatment.

Naturally the question of the specific heat of superheated steam formed a detail of the subject, and the general result was to emphasize the necessity for further original research. The present tendency is to accept the later work of the German investigators Knoblauch, Lorenz, Jakob, and others, and to work these over as the original experiments of Regnault have been treated in connection with saturated steam. There is good reason, however, for the demand for a complete re-investigation of the whole subject, not a threshing out of old experiments, but a complete re-determination of all the elements required in modern steam engineering. There is every reason to believe that Regnault's work was entirely trustworthy as far as it went, but pressures and temperatures now used cover a much greater range than was included in his researches, while methods and appliances have been improved, and the number of experimental laboratories available for the work render it possible for the investigations to cover a far greater number of determinations than was possible sixty years ago.

An important detail in the satisfactory use of superheated steam exists in the matter of transmission losses. It is beginning to be realized that the degree of superheat produced at the generator is by no means delivered to the engine if any considerable length of piping has to be traversed.

There appears to be some relation between the heat losses and the velocity of flow of the steam through the mains, and while the law has not been definitely determined, it seems to be admitted that high velocities are necessary, and that with low rates of flow nearly all the superheat is lost. In this connection it is of interest to note that those plants in which the greatest benefit has been derived from superheating have been the ones in which the distance between the superheater and the engine was very short. The Wolf semi-portable engines, which have given remarkable results with engines of moderate size, are arranged with the cylinders on top of the boiler, and in such a position that the steam flows almost directly from the superheater into the high-pressure cylinder of the compound engine; and when re-heating is used a similar short connection exists. Dr. Berner, than whom probably no one has studied the subject more thoroughly in recent years, admits that our present knowledge of the transmission losses is extremely small, and undoubtedly the best plan in superheated steam installations is to make the transmission distance as short as possible.

ADOLF BENDER

By Louis Baron

IN the course of the development of machinery for artificial refrigeration there has grown up in the United States a business which has had its own path to blaze and its own methods to create. The manufacturing side of the industry involved the production of machinery of a high order of excellence, designed in accordance with the fundamental principles of thermodynamics and constructed by means of the latest methods of the machine shop. To these it has been essential to add the efforts of a business administration especially adapted to the solution of the industrial and commercial problems which have presented themselves, so that, taken as whole, the business, as it stands to-day, may well be said to represent a unique department of industry.

Among the various firms which have engaged successfully in the creation of this important industry none is better known than the De La Vergne Machine Company, and its position to-day is represented in a characteristic manner in the person of its president, Mr. Adolf Bender.

Mr. Bender is a native of Germany, having been born in the year 1853 at Hohensolms, near Coblenz-on-the-Rhine. His inclination to mechanical pursuits was acquired, both from his father, who was an officer of artillery, and in a corps of engineers under the Prussian Government, and from his brother, an engineer of prominence largely identified with the development of the iron and steel industry of Germany, and director general of the Siegen-Solinger Guss-Stahl Werke.

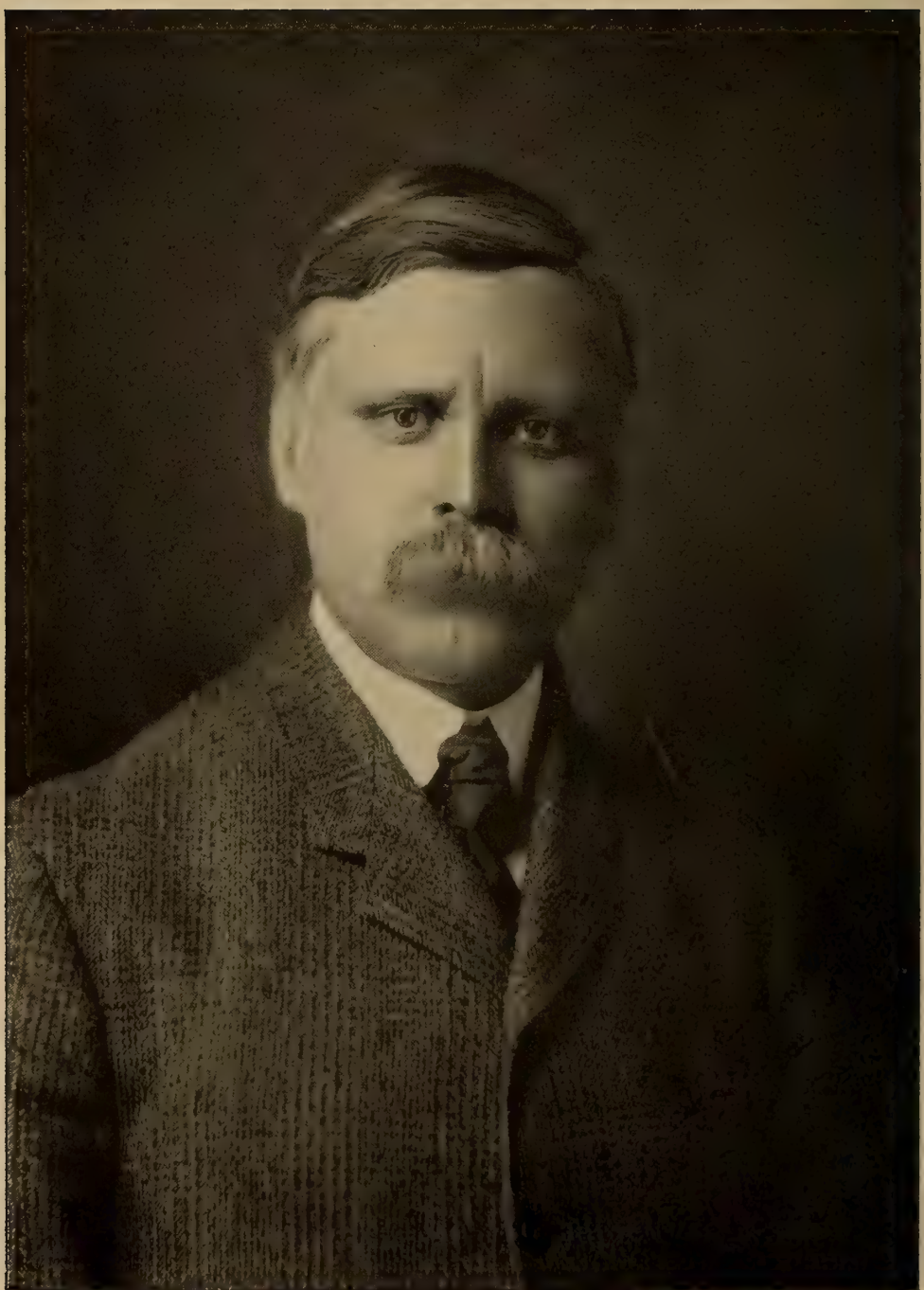
After receiving his education at the Royal Gymnasium at Coblenz, and at Elberfeld, Mr. Bender entered the textile industry, serving his apprenticeship with one of the largest houses in Elberfeld and then entering the commercial department of the business in the same city. At that time it was the custom, as it still is, for a young man to complete his business education by visiting some foreign country. With his father's approval, young Bender chose America for his new field in preference to England or South Africa, and in 1874 he came to the United States, equipped with excellent credentials to A. T. Stewart & Co., H. B. Claflin & Co., C. F. Dambmann & Co., and B. L. Solomon & Sons, all large buyers from the house in Elberfeld where he had served his apprenticeship. Unfortunately, however, Mr. Bender suffered from serious illness at the time, and this, together with the business depression in America, rendered it unadvisable for him to remain, and after two years he returned to Germany, remaining in Europe until 1877, when he again came to America.

From this time until the present Mr. Bender has continued in the United States, extending his business education and becoming, in 1885, a salesman for the F. W. Wolf Company, of Chicago, and then entering the employ of the De La Vergne Machine Company, rising successively to the positions of sales

manager in 1894, general manager in 1896, and later to the presidency of the company. During this period the business of the establishment has developed steadily until at the present time its quarters, occupying three city blocks at the foot of East 138th street, in New York City, are becoming altogether inadequate for the demands of the business. Apart from the manufacture of the De La Vergne refrigerating and ice making machines, the company has undertaken the construction of internal-combustion engines, and has been most successful in the introduction into the United States of the Hornsby-Akroyd oil engines, and the Koerting two-cycle and four-cycle gas engines for use in iron and steel works, and in power plants.

Personally, Mr. Bender is a broad-minded man, of quick perception, great energy and very strong character. He is decided in his views, has a keen sense of honor, justice and fair dealing in business, and is very firm in demanding the utmost loyalty on the part of all his employees. He is an exceedingly frank and candid man, disdaining all artifice, never hesitating to express his honest opinions in a plain and direct manner, and with a courage that never falters.

Socially, Mr. Bender is a charming gentleman, a princely entertainer and a most welcome guest at the firesid. of his many friends.



CUMMINGS C. CHESNEY

FIRST VICE-PRESIDENT AND CHIEF ENGINEER OF THE STANLEY G-I. ELECTRIC CO., PITTSFIELD, MASS.

(SEE PAGE 376.)

PATENT OFFICE
INDEXED

CASSIER'S MAGAZINE

VOL. XXXII AUGUST, 1907 No. 4

REFRIGERATION AS AN AUXILIARY TO THE POWER PLANT

By Joseph H. Hart, Ph. D.

The present tendency of engineering work is toward the reduction of wastes in all departments, and to the utilization of the maximum proportion of the entire product of the plant. This is seen in the extension of the utilization of the gases discharged from blast furnaces by employing what was formerly a waste product to the operation of gas engines, a large amount of power thus being obtainable without the combustion of additional fuel. In the case of the steam power plant, the exhaust steam is sometimes used for heating, but it is now proposed to utilize the exhaust steam for the evaporation of ammonia in connection with the absorption process for the production of cold. Dr. Hart discusses this feature of the problem of mechanical refrigeration, and shows that the value thus obtainable from exhaust steam may work a marked change in the design and operation of steam-power plants. The whole question is of especial interest at the present time, and the principles upon which the action is based are here clearly presented.—THE EDITOR.

MECHANICAL refrigeration is a branch of engineering familiar to many but understood by few. Its present position in the engineering world and the changes which are constantly going on not only in regard to relations between its various divisions and their relative efficiency but also in connection with outside engineering developments, are little understood. The general status of mechanical refrigeration has changed to such an extent within the last decade that it presents practically a new science to the engineer. As a general statement we can say that all refrigerating machines may be classified into three groups: those employing air as a refrigerant; those employing the mechanical phenomena of absorption and solution of ammonia by water, and those using liquefiable gas.

There is one other type generally recognized as thoroughly inefficient which is in existence to-day in some minor plants, viz., the vacuum process. In this water vapor is withdrawn rapidly from the space above the surface of the water and the production of new vapor which is in turn removed, absorbs the heat of liquefaction from the water thus producing ice. It is in reality a subhead under the liquefiable gas machine in which the liquefaction is of minor significance and unnecessary. However, this machine exists to-day only in small isolated units and the

 Copyright, 1907, by The Cassier's Magazine Co., New York.

remarkable mechanical inefficiency of the removal of the water vapor is responsible for its present position.

Now the air machine is clean and odorless and is somewhat in use on shipboard. It utilizes the process known as balanced expansion, whereby the air is cooled by doing work in a cylinder. Its size, weight and cost and large consumption of power are serious drawbacks to its wider use and it is now recognized that its field is limited to places where the use of other types is prohibited.

The absorption machine has a rather complicated mechanism. There are no moving parts except a small slow speed pump and it possesses a distinct advantage on this account. Its agent is ammonia and it was generally regarded up to about the year 1895 as an extremely inefficient process.

The liquefiable gas machine was considered the most efficient, the simplest and most convenient. A gas was liquefied by mechanical compression, followed by cooling, and this liquid was then allowed to evaporate and absorb its latent heat of liquefaction from surrounding bodies and the process was made continuous. Ammonia, sulphur dioxide, ether, methylchloride, gasoline and carbon dioxide, and any one of an even larger number of what are known as volatile liquids have been used. From theoretical considerations and practical details combined, it has been shown conclusively that ammonia is probably the best substance for the conveyance of heat in refrigeration and the majority of compression machines to-day utilize this material, although carbon dioxide, on account of its physical properties and diminished cost, has replaced it to a certain extent in some of the smaller units.

The absorption machine, so-called, which utilized water in conjunction with ammonia gas, was the first practical refrigerating machine; but later came into considerable disrepute on account of its remarkable inefficiency. The gas is produced from the aqua ammonia by steam coils in a generator somewhat similar in construction to the modern boiler. The pressure was increased by means of heat until the gas could be liquefied with cold water and it was then evaporated in a manner identical to that of the ammonia compression type. The expanded gas instead of being conveyed into a compressor as in the latter system was absorbed by cold water or weak aqua ammonia. This system requires five distinct units; the generator, where the gas is produced; the dehydrator, where the excess water vapor carried over by the gas is condensed and removed; the condenser, which consists of pipes having cold water flowing over them and in which the gas is changed to ammonia liquid; the expansion coils or shell cooler, in which the refrigeration is produced; and the absorber, which absorbs the gas back into the weak aqua ammonia, completes the process. Further an ammonia pump must be installed to force this liquid back into the generator, thus making the process continuous. The compression system, on the other hand, utilizes simply a compressor and condensor and the refrigerating apparatus or shell cooler. This mechanical compression type was formerly superior although it depends on the operation of a compressor which is mechanically of low efficiency. Both types of machines, however, are dependent for their efficiency upon design to an extent which was not realized until recently and the situation exists to-day that the absorption system is the superior in many ways when used in large units.

As an illustration of this latter point it can be cited that the absorption system has its efficiency limited directly by the action of the dehydrator. If water vapor is carried over with the gas and not separated, it condenses in the condenser in the production of liquid ammonia and combines there directly with it, forming strong aqua ammonia; the refrigerating power of the ammonia being

counterbalanced by the heat of combination at this point. Thus the entire problem in the absorption system depends upon the design of the generator and its efficiency in producing rapidly comparatively pure ammonia gas without water vapor and upon the efficiency of the dehydrator in removing the residue of the water vapor before it becomes objectionable. The design of the absorption system was not fully studied until within the last decade. Both types of machine depend absolutely for their efficiency on their design. An absorption plant may operate with the production of no refrigeration and a compression plant may do the same, the result being due to faulty design in both cases.

The absorption machine employs the heat in the steam for the production of the ammonia gas from the aqua ammonia. It thus utilizes the latent heat of vaporization of steam, and high pressure superheated steam increases the efficiency but slightly. A compression type utilizes the expansive force of steam only and hence superheated compound condensing engines are the rule in large installations of this type. Thus we come to the anomalous condition that the absorption machine can utilize exhaust steam very efficiently, whereas the compression plant has its best efficiency with high-pressure superheated steam, and does not utilize the heat of the exhaust at all. The claim is often made that the absorption machine requires more heat in its operation than the compression plant, and while this is true, when the quantity of heat taken from the boiler is considered the absorption system is much superior. Thus in large units —in the production of ice, for example—a compression plant operates generally on an 8 to 1 basis; that is, 8 tons of ice produced to 1 ton of coal consumed. An absorption system under the same conditions can operate on an 11 to 1 basis, whereas a combination plant of the same total capacity for compression and for absorption, the exhaust steam from the compressor operating the absorption system will operate on a 14 to 1 basis. These figures in general have a 50 per cent. range of applicability, depending upon maintenance of plant and method of operation; but there is no doubt, in large units of 100 tons capacity or more, that the absorption system, or better, a combination plant, is much superior. This is in complete contradiction to the generally accepted opinion ten years ago, and is due to improvement in design of the absorption system whereby the exhaust steam can be utilized efficiently and in which heat waste has been comparatively eliminated.

This brings us to a remarkable condition in the engineering field. It shows a further application of the utilization of exhaust steam never before seriously considered. Exhaust steam has been used generally for heating purposes and in some isolated cases for drying various materials. Its application to mechanical refrigeration in power plant production has progressed to a certain stage. It has been generally recognized that such units as the lighting or trolley systems have excess loads in the morning and evening. Formerly this was taken care of by storage batteries but their rapid deterioration and general cost of maintenance was such that it has been found preferable to operate a full size plant for the load at maximum. This is due partly to the increased efficiency of large plants and to the necessity of a choice between two evils. This latter situation presented a large excess power available at slack time and this excess has in some cases been sold to small refrigeration consumers operating their own plants. Mechanical refrigeration possesses this further advantage in this field. It can be operated intermittently. Thus by the use of a large brine storage tank refrigeration can be produced in the brine and kept here for long periods of inactivity with small waste and utilized when wanted. Thus the

power plant in its development has aided the development of a large number of small unit refrigerating systems by the furnishing of sufficient power at minimum cost at irregular intervals.

Further, owing to the ability of mechanical refrigeration to operate intermittently and in reality to take the place of the storage battery in the storage of energy, it has found a place in the modern plant. Thus many small trolley and lighting systems operate a refrigerating or cold storage plant as well. The excess current being turned into refrigeration when not needed and the cold brine carrying this system over the inactive period when power was needed along other lines. This has proved extremely efficient, and in many of the smaller cities such plants are in active operation.

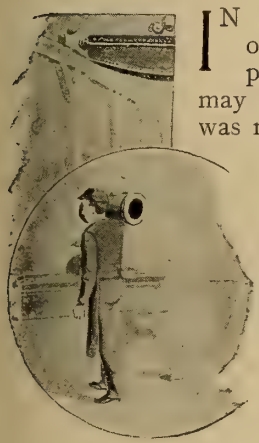
The advent of the absorption system with its remarkable increase in efficiency threatens to produce a change in the present conditions. Modern power plants in large units require complicated prime movers using superheated steam and generally of the compound condensing type whose cost of maintenance and high first cost is often almost prohibitory. The absorption system cannot use efficiently high pressure superheated steam. The compression plant itself is inefficient in the production of refrigeration. Hence, it, in turn, will be displaced for large units, and we shall have the rather anomalous condition of large refrigerating concerns with excess power for sale, using simply plain slide-valve engines of low efficiency and large steam comsumption. Such a plant could sell power as a by-product in quantities and at prices such that the ordinary unit in this field could not compete. Further, the modern power plant has an additional by-product available in the utilization of its exhaust steam in the production of mechanical refrigeration. The interrelations between these two engineering developments are at their inception and time only can develop the exact situation. However, conditions are such at present as to point almost conclusively to a radical change in their inter-relations and a complete innovation in the production of power.

INDUSTRIAL AMERICA

A MACHINE-SHOP REVIEW—II.

By J. E. Livermore

In the previous issue Mr. Livermore described the impressions made upon him at the time of his first arrival in the United States, with especial reference to the surroundings in the shop, the provisions for personal cleanliness, lunch rooms, etc., and their relations to the efficient operation of the machine shop. In his second, and concluding article, he examines the all-important matter of apprenticeship, and the training of the young men who are to be the skilled mechanics of the coming generation, comparing American practice with that of Great Britain, as it appears to a man who is familiar with the shops on both sides of the ocean.—The Editor.



IN speaking of the use of drawings and blue prints in this article, I may note one thing which was rather a surprise to me. Many people have been under the impression that when a man makes a mistake in the States he is promptly kicked out of the shop. I did not find it so, but on the contrary, I found that when a mistake was made there was a very keen desire to find the cause of the mistake and prevent it from happening again. Here is an instance: A piece of work had to be finished to 2.005 inches in diameter. By some means the figure five had got blurred, and the man who finished the shaft read the drawing as 2.003, consequently, the piece was .002 under size. On inspection this was at once found out, and within fifteen minutes there was a meeting (of several men interested) on the spot where the work was done. It included the superintendent of the shop, the draughtsman who checked the drawing, the inspector, the foreman of the job and the man who did it. It was an oversight. The draughtsman remembered the figure, but admitted it was not plain; the workman read it wrong, but did not question the foreman on it. The inspector found it by having a copy of the original figures which he would use to check the finished work when it was inspected, it would perhaps be a bit unfair to blame anyone, but the figure on the drawing at once had two red lines put through it, and a fresh number in red figures put on, with the date. This was done at the foreman's desk and the affair ended.

I have seen mistakes quite as simple in an English shop, but they were not settled so promptly, generally the mistake would not be discovered until the machine was being put together, and then the trouble was worse. If, as in this case, inspection follows the work quickly through all its stages, a mistake is soon found. It is not always the loss of material, but the loss of time is very often a much more serious matter. In conversation with the superintendent afterwards he informed me, that they always looked after the little mistakes that way, as they wanted to hear both sides of the question, since they did not believe that a man would deliberately do a thing wrong if he knew of it. This seems to make out a fair case for the inspector, and although he may be a costly man, we cannot do without him. Close inspection during every part of the work is necessary if good results are to be obtained. In most cases if the American employs only twenty men he would have an inspector, even if only for the sake of making someone responsible.

It would hardly be fair to pass

AUDITORIUM AND LIBRARY. J. H. WILLIAMS & CO.'S DROP-FORGING SHOP, BROOKLYN, N. Y.

over the machine shop without speaking of the working hours. I must confess that I very quickly fell into American ways. First of all, breakfast about 6.30 A. M. and begin work at 7.00 A. M., then stop at 12 o'clock for dinner and work again from 1 o'clock till 6 P. M., and on Saturdays from 7 till 12, and 15 minutes allowed to clean up machines. This time seemed to me to be a sort of standard in use all over the country, and for my own part I think it a very much better method than beginning work at 6 o'clock and working until 8.30 before having any breakfast. The American style gives only one break in the day, and the breakfast puts some steam into a man to help him with his work; he does not want to watch the clock to see how long it will be before he can get something to eat. Both systems, I dare say, have their good points, but I believe in the old proverb which says "A job well begun is half done," and I fail to see how a day's work can be well begun when one has to turn out of a comfortable bed (in the winter especially) at 5 o'clock and possibly walk from one to two miles and then do two hours' work with an empty stomach. Furthermore, there is the saving of gas or electricity for the first hour, and in fact, in America, it always seemed to me that the atmosphere was very much clearer in the winter months and the need for artificial light was very much less than in England.

The question of warming and ventilating the workshop is one that has come in for a great deal of discussion. I found all the American shops nicely warmed, in fact, to me they seemed hot, the temperature frequently being from 70° to 75°. The American workman likes a warm shop, and even at 75° he does not show any signs of discomfort, but to the Englishman this temperature is too high, 60° is as much as he would

LECTURE ROOM IN THE FACTORY OF THE NERNST LAMP COMPANY, PITTSBURG, PA.

care about, and for my part I quite agree with him. The method of heating is generally by steam heat and hot air, and many shops have both. With respect to this heating of workshops, it must be fully understood that it is not entirely the men's welfare which is being considered. We all know that it is comfortable on cold mornings to have this heat, but I believe the chief thing to consider is the climate of North America. In New England the winter is something to reckon with, and as many of the high class tool shops are situated there this heating is an absolute necessity. Furthermore, all light automatic machines of any description work very much better in a warm even temperature, a grinding machine is a much more reliable tool when the temperature is kept even, and the same will apply to all machine tools. Although the results are not so pronounced as in the two classes of machines mentioned above, considering the nature of the American winter, I think the manufacturer must be congratulated on the regular even standard of his product.

The American workman is a man who is well informed and I found quite a number who were very keen on enquiring into industrial conditions existing in England. Didn't I think a man who ran two machines in the States for $18 a week is better off than a full fledged mechanic who got £2 per week in England, and when I had thought the thing over, and lived there for a time I was compelled to admit that as far as my observation went, the American had he best of the deal. He would take it this way, $18 per week is about 75*s*., then take 25*s*. for board and lodging in the States, this left 50*s*. Then take the Englishman's wage, 40*s*. per week, less 15*s*. for board and lodging, this left 25*s*. Here is a difference of 100 per cent. That many things are dearer in the States than

TRAFFORD INN. THE WESTINGHOUSE MACHINE COMPANY, TRAFFORD CITY, EAST PITTSBURG, PA.

in England I admit, but having tried both, the American with the 50 shillings left is the better off of the two. In most cases the housing accommodation is better for the American, the rent is very little above that of the large towns in England. while if the districts are new, such inducements as free taxes, free water, etc., for about three years are offered, and land freehold is quite as cheap as in England. Clothes cost more money, and the cloth in the States is not so good a quality as we might get in England, but the American will most likely buy three new suits to the Englishman's one, and will pay from $20 to $25 for it. I did not find prices of domestic stuff much higher than in England. For instance, a pair of boots in the States sells at $4; the same boots are sold in London for 16*s*. 6*d*. Can the Englishman afford to buy at the same rate as the American. I think not. It is only fair to add that the wage of $18 is not a standard. There are machine operators who only earn $15, some only $12, but there is also a lot of piece work, which easily rises above $18, and there are tool makers who earn up to $25 per week, and so do a number of mechanics. In England too, all mechanics do not earn £2, many only 36 shillings, while machine operators make from 28*s*. to 34*s*. per week, so that the wages I have taken are a fair comparison.

While discussing this subject it will perhaps be well to see how the American workman is made; assuming that a mechanic is made and not born, the making may be of some interest. The following particulars are some that I have been able to gather, and are I think fairly good. They were taken from a firm who are most careful in the choice of a boy, and who have realized that the boy makes the man, consequently they have adopted a very thorough system of training and one which gives good results. When it comes time for him to be apprenticed he does not go to a shop because it happens to be in the same neighborhood as his house or because his father works there. Whether he goes to the shop at all is a point which is most carefully considered by the head of the firm. There is no question of gentlemen apprentices, all are equal. The first thing sought for is good personal references. This being satisfactory, a step farther is taken and the boy's education comes next; also age, which is generally about 18 years or may be more or less. There are of course exceptions. He will be taken on trial for about three months. During that time he will be under very close observation, and if the firm come to the conclusion that he is not in love with the work and not likely to take an interest in it, he will be told that he is not suitable, and advised to at once take up some other business which would be more to his liking. If, on the other hand, the firm is satisfied he would be asked to sign an agreement, and pay a small premium somewhere about $50 and start in for a four years' apprenticeship. For his work he is responsible to the foreman of the department, but for his training he is looked after by a careful skilled man who will have charge of all apprentices. This man will most likely visit him twice every day. He will explain to him very fully the machine he is using. He will point out where the chances of error in work may come in by improper use. He will explain the design of the tool, why it is so designed, and will make a note of the work the boy is doing, and take such notes as will help him to form accurate judgment for future times. If the boy is a stranger in the town, this man will see to it that he has a proper lodging, and after working hours he will give him any information dealing with further study. In fact he is in the works to assist these boys in every possible way for their benefit. Having got the boy started, most likely on a drilling machine, the date of commencement is entered in a

READING AND WRITING ROOM, TRAFFORD INN, TRAFFORD CITY. WESTINGHOUSE MACHINE COMPANY, EAST PITTSBURG, PA.

book, and the time he spends on this machine will be determined by the quality and quantity of work turned out. As soon as he is started the man in charge of him will have a straight talk with him on two vital points. The first is, in all cases, to aim first at accuracy and a clear understanding of just what is required, and speed will then follow as a matter of course. The second point is, always bear in mind, that the work in hand is of a commercial nature. The work is a part of something which when finished is placed on the market and sold in open competition. It is necessary for the firm to make a profit for money invested. They must therefore be able to manufacture at a price which leaves no chance for their competitors to undersell them. Therefore, always remember that everything made has to be sold, and the time taken to make it in is a very vital question to bear in mind. From a drilling machine, the boy will be put on a lathe, the same thing follows here, instruction is given in every form, the lathe fully explained. This machine is not in the writer's opinion looked upon in quite the same light as in England. Here a lathe is thought a great deal of. In an American shop no work goes to a lathe if it can be dealt with in any better way. There appears to be more vertical boring and turning and chucking machines and special tools doing lots of work which is still done on a lathe in England. His next move will be to a universal milling machine. Here he will stay as long as on any machine; simple jobs at first, and then as time goes on his work is improved, and he is made thoroughly familiar with the use of a spiral head, everything being noted, and the time booked that is spent on the machine.

The next move will be to do scraping work, and prepare surfaces, etc. This takes some time, and from this he will go to a planer. In this move it is opposite to English custom. A

planer hand in England is not considered quite so good a man as one who would do scraping and lining up. But the American takes a different view. They believe that if an apprentice gets an overdose of scraping, or in other words, if too much is left on a casting and he has to scrape it off, it is the best possible way to teach him how close to finish a job when planing it, while the man works there is generally an Association of Apprentices, who meet every week, when the boys in the last year of their time read a paper on some mechanical subject, after which a discussion follows, and occasionally a gentleman from another works (not necessarily engineering) will be invited to give a lecture. In the last year of their apprenticeship the boys will be taken about the works, new

LIBRARY AT THE WORKS OF THE WESTON ELECTRICAL INSTRUMENT CO., WAVERLY PARK, NEWARK, N. J.

who does all planing and no scraping often leaves a lot of hard work which is costing far more to be done by hand scraping than he has any idea of.

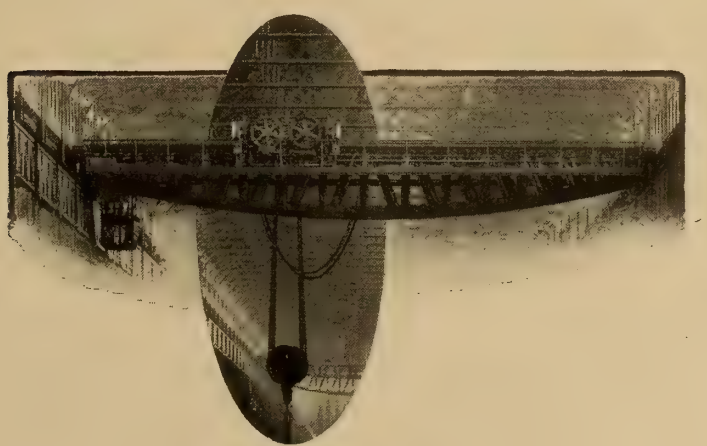
The next move now is to assembling. Here our boy will see the pieces that he has machined put together, and made ready for building the machine, and up to this stage he will most likely have spent three years of his time, and the last year is spent on erecting machines. This is the most important year. In the and special plants will be visited, and the details explained. They will also visit other works, and no opportunity appears to be missed which helps to increase their knowledge.

There are one or two things which these boys do not get on to. One is, the use of a file. They do not get nearly so much practice as the English boy, but I do not consider it any drawback. They claim, and rightly too, I think, that the machine finish wherever possible is the best and cheapest, also that the day of hand

finish is passing, that it is harder work. They therefore dismiss the file, and go in for machine finish. The apprentices do not get any direct work on grinding and sharpening cutters, but while they were doing machine work they were taken to the tool room and all this explained. Consequently the actual sharpening does not present any serious difficulty. This time, we may say, has taken up the four years, and I think few will be inclined to think it forms a bad start. It is true a lot of the work is jig work, that a lot of the turning has only been rough, as the grinding machine is used for finishing, but for all that the boy has been well taught and trained in a way which is best suited to the method adopted in this country. On the last day he will be sent to the office, his record having been gone through and found satisfactory. His premium will be given back to him, and double the amount added to it in most cases. His pay has probably been 6 cents per hour for the first year, second 8 cents, and so on up to the last year. Many of the boys make their way up to the drawing offices after their apprenticeship is finished. Some move off for further experience in other shops. Since seeing these boys in various shops, I have thought whether we in England are doing exactly the best possible for the boys here. Perhaps English boys would think their liberty was being interfered with if they were watched too closely, but I think at the end of the time when they had grown a few years older they would probably be thankful that they had good advice when younger. I for one do not believe in taking a boy into the shop as an apprentice to fitter and turned, and leaving him to learn and get his information from the men he happens to be working next to. He does not always learn what is best, and from what I have seen, I have come to the conclusion that it would pay to give a little more time to the boy. At present a good deal of attention is being given to the study of foreign languages in the States. Machine-tool builders especially realizing that the men trained in their shops, and these being sent on the Continent to make them master of the language, and to enable them to talk to possible purchasers in their own tongue is the most effective representation they can get.

I found during my observation of machine shop work in the States, that there was a very real desire to arrange things so that a boy who was studying in the evening, and those who were at college, should have their work arranged so that the subjects of study should be brought to bear as much as possible on the daily work. It is a common thing to hear a young man say that he does not see where the theory he is learning helps him with his shop work, and it is possible to-day to see advertisements where a man applies for a position and states that he is able to tell whether a machine is earning a dividend or not without consulting a text book. This is all very nice, but I was never aware that a text book was intended for that purpose, but it certainly does play a very important part in design, and as a thing has to be designed before it is made, this stab at the text book rather misses the mark. As an instance to prove the statement I have made in bringing students more into touch with the actual work and combining theory and practice, the following notes were taken from the catalogue of Massachusetts Institute of Technology. Lectures are given by gentlemen who are immediately engaged as managers and superintendents of different industries. In the class for chemistry, the following are mentioned: The Chemist of the Pacific Mills on Textile Printing; A Consulting Expert on Cement Manufacture; State Inspector of Gas and Gas Meters on the Manufacture of Illuminating Gas; Consulting Chemist on the Manufacture of Papers; General Manager of the Merrimac Chemical

Company on Alumina and Alumina Compounds. Electrical engineering was represented by the following gentlemen who lectured and who do not belong to the Institute: Electrician of the Boston and Albany Railway on the Application of Electricity to Railway Signalling; The Electrical Engineer of the American Bell Telephone Company on Telephone Engineering; C. J. H. Woodbury, of the American Bell Telephone Company, on Electricity in its Relation to Fire Risks; Dr. Louis Bell, on the Electrical Transmission of Power and the Application of Electricity to Railway Transportation; Mr. Doane, of the Marlboro Electric Company, on the Manufacture of Incandescent Lamps; Mr. Roberts. on the Nature and Function of Patents for Inventors. In the Mechanical Engineering Section special attention is given to the study of the mechanism found in modern American machine tools and cotton machinery. Mechanical drawing aims to teach the proper way of making dimensioned drawings, tracings and blue prints for use in practice, a good shop system being adopted. Lectures were also given by several gentlemen, one lecture on Electric Driving in Cotton Mills, and one on a subject not mentioned, by Mr. S. M. Vauclain, General Superintendent of the Baldwin Locomotive Works, in Mining Engineering and Metallurgy a little change is made. This branch has a summer school, and to get into closer acquaintance with their profession the party visits a locality with their instructors where the various works are in progress doing actual work and making a systematic study of the different operations and writing up the notes from day to day. The districts visited in one year were, New Jersey, Eastern Pennsylvania, Maryland, Baltimore, United States Mint at Philadelphia and a number of up-to-date steel works. In the following year the summer school was held in Nova Scotia and Cape Breton (English reader please note). Surely this is a valuable experience and much good should result from it. My view, taken as a workman, is that the American boy had much the best start, and if he is smart at his business it is because he has been made so. He is as much the product of a careful well thought out system, as the machine he builds and operates.



ELECTRIC POWER TARIFFS

By C. S. Vesey-Brown, M. Inst. C. E.

THAT branch of the electrical industry which is occupied with the generation and sale of power in large quantities has developed rapidly during the past six or seven years.

The moment is therefore opportune for a review of the charges made by such undertakings as are doing business on a large scale, with a view of showing what is the practice in this respect.

Ten years hence, the supply will be on a larger scale than it is at present, and developments in the direction of using combustion gas turbines will probably have reached another stage, and if such be the case one may look forward to possible reductions in the charges for electric power.

For the present, one can only consider the charges made by hydro-electric and steam generating plants.

The efficiency of a system which uses steam is considered good if it reaches 6 per cent of the caloric value of the fuel. The only improvement on this percentage known at present, is where either natural, blast furnace or the waste gases from the carbonization of coal are utilized in internal combustion reciprocating engines or directed under steam boilers.

In these cases it is difficult to arrive at the efficiency of the system, and the few examples of public supply from such sources do not furnish data as to the charges made by purchasers of electric power.

On the other hand there is a mine of information obtainable as to the prices of supply where steam or water power are used, and from the particulars thus available this article has been compiled.

The assistance of those who have kindly furnished statistics is hereby gratefully acknowledged.

The most vital matters connected with electric power supply are "reliability of service" and the relation between selling price and return on the capital invested in the business.

The former condition affects entirely the technical side of the power plant, and it is not a difficult matter so to design an electric power system, from the prime mover through the different stages of generation, transmission and distribution to the consumer, that the reliability of the service shall be invulnerable to the ordinary everyday demands on insulation and overload, and which may even withstand the extraordinary differences in temperature, weather conditions, earthquakes and minor subsidences such as occur in mining districts.

To "run" such a plant to the best advantage for both investor and consumer is, however, a matter which calls forth a management which must be trained to deal with commercial and technical problems of the highest order. To develop a demand on the power plant which will load it effectually and return a reasonable profit on the transaction is an art which requires cultivation. Many and varied are the tariffs for electric power which are placed before power users and an investigation into the different methods of charging is in-

structive as disclosing the ingenuity of the "Commercial Power Engineer" to increase his "sphere of influence."

The management of any industrial undertaking is based on what is termed the "turn-over" of the capital invested in the business. There are exceptions to this rule, and none which are more difficult to explain to the lay mind than that of an electric power supply business.

The capital employed in an electrical installation is invested for the purpose of giving a supply of power, and once incurred cannot be recalled without severe depreciation. It is not in the same category as the capital employed in a business, which either buys manufactured articles wholesale and retails at a profit sufficient to cover the redemption of capital, or where raw material is turned into manufactured goods.

The capacity of the annual "turn-over" of an electric power plant is limited to the total amount of kilowatts that can be turned out from the plant per hour multiplied by 8,760. The aim of the manager of an electric power business is to get as near the result of this multiplication as possible.

Investigations into the tariffs in operation in a great number of power stations throughout Great Britain, the British Colonies and in some European works, show that the standardization of the price is what one may call "local," and that absolute uniformity in all countries is impossible in view of "local" circumstances.

The electrical power engineer and manager knows to the last decimal place the extent to which the price of supply may be offered when based on the principle enunciated by the late Dr. John Hopkinson, and it is for this reason that in the majority of cases the tariffs are devised to give the power user who understands and considers his "load factor" the lowest terms compatible with this factor and a reasonable return on the capital expended by the power company.

Briefly put, Dr. Hopkinson's principle showed clearly that the heaviest cost of providing electric supply was in the capital expenditure and that the "running" costs were small as compared to the interest on the capital outlay.

From this it will be seen that the longer the use is made of the energy the smaller the rate per kilowatt-hour (or whatever standard is taken) will be.

Mr. Arthur Wright, the first president of the Municipal Electrical Association, elaborated these principles in a paper read by him at the first meeting of that association in 1896. In that paper he gives two classes of expenditure to be taken into account, viz:—

(1) Standing charges to keep the plant ready to supply, including interest and redemption of capital, and

(2) The actual "running" charges.

The doctrine of charging for electricity on these principles has been followed by every municipality owning electricity works in Great Britain, and until the day arrives when the output is so great that an average price is capable of being struck for all classes of consumer, there is no doubt about its efficacy in improving the "load factor" of an electric power station.

It is, however, a difficult matter to explain this principle satisfactorily to the consumer, who may be a man who sells beer, or flour, or other commodities by the barrel or the sack, the ton or the pound, the mile or the inch, etc., that the principle on which such a tariff is based is not only a sound, but the right one. He answers by saying that if he charged 5/ for the first glass of beer and a ¼d for each succeeding glass drunk during the year, that he would not do any business, and like arguments are possible in other trades.

For such power users the power company has to devise a flat rate and system of charging and vary the actual cost to the user, by discounts depending on the annual consumption, taking

the risk that the load factors of different consumers will balance.

Electro-chemical processes, railway and tramway service, continuous and intermittent supply for pumping and ventilating in mines and the hundred and one mechanical operations in engineering workshops are now fairly known and the price of supply can be gauged to a nicety in most cases.

In analysing the different tariffs in operation one is struck at once by several prominent features in the result of the analysis.

Those of the hydro-electric power stations have obviously been arranged to give the long-hour user every benefit, and the principles which have led to English practice in giving the manufacturer who only employs for an average 3,000 hours per annum, has not sunk so deeply into the minds of those responsible for framing these tariffs, as in England. They have looked to the long-hour user to recoup them for the capital outlay, whereas in England, it is the short-hour user who is the mainstay of electric power supply.

Typical cases of 15 horse power and 50 horse power users are given in the following tables, which show what a man will pay for his power if his factory is in different countries:

COMPARATIVE RATES CHARGED FOR POWER UNDER VARYING LOAD FACTORS, BY DIFFERENT ELECTRIC POWER SUPPLY AUTHORITIES.

DISCOUNTS FOR PROMPT PAYMENT NOT TAKEN INTO ACCOUNT.

Price given in Pence per B.O.T. Unit. 25 Francs = £1. 1 Dollar = 4*s.* 2*d.* 1 Rupee = 1*s.* 4*d.*

LOCATION OF SUPPLY.		LOAD FACTOR, PER CENT. 15-hp. Motor Absorbing 11,250 Watts Per Hour.									
Authority.	Method of Generation.	10	20	30	40	50	60	70	80	90	100
SWITZERLAND.		*D.*	*D.*	*D.*	*D.*	*D.*	*D.*	*D.*	*D.*	*D.*	*D.*
Beznau	Water	2.68	1.34	.895	.67	.645	.586	.504	.44	.387	.352
Rheinfelden	Water	2.34	1.24	.87	.704	.597	.528	.484	.447	.415	.394
Average of Swiss power stations (fixed rate)	Water	2.859	1.48	.955	.714	.....	.....	.....	.....	.....	.....
Average of Swiss power stations (meter rate)	Water	3.18	1.84	1.25	.92	.....	.....	.....	.....	.....	.....
CANADA.											
Hamilton	Water	1.075	.78	.67	.67	.67	.67	.67	.67	.67	.67
Montreal	Water	5.25	2.66	1.78	1.33	1.065	.885	.75	656	.584	.525
British Columbia E. P. Co., Ltd.	Water	1.6	1.31	1.2	1.15	1.12	1.1	1.08	1.075	1.066	1.06
INDIA.											
Mysore (Kolar gold fields supply 92 miles)	Water	3.66	1.83	1.22	.915	.735	.61	.524	.457	.403	.366
Mysore (Bangalore local supply)	Water	4.08	2.04	1.365	1.02	.82	.684	.586	.513	.45	41
AFRICA.											
Rand Central El. Works	Steam	5.16	3.075	2.4	2.04	1.83	1.69	1.6	1.52	1.45	1.41
GREAT BRITAIN.											
Newcastle Electric Supply Co.	Steam	1.35	1.3	1.28	1.275	1.27	1.267	1.263	1.262	1.261	1.26
Yorkshire Electric Power Co.	Steam	2.145	1.54	1.337	1.237	1.177	1.136	1.107	1.086	1.069	1.056
Clyde Valley Electric Power Co.	Steam	2.130	1.52	1.319	1.21	1.146	1.11	1.08	1.055	1.04	1.023
Glasgow	Steam	1.5	1.29	1.11	1.023	.968	.932	.906	.886	.871	.86
Midland Electric Corp'n.	Steam	1.5	.95	.95	.95	.95	.95	.95	.95	.95	.95
Derby & Notts E. P. Co.	Steam	1.35	1.055	.838	.728	.663	.619	.588	.564	.544	.535
London County Council (proposed charges, 1907 Bill)	Steam	2.179	1.255	.946	.792	.699	.638	.594	.561	.535	.515
Ideal steam station based on total cap. exp. of £30 per kw. of plant and distribution; coal at 8*s.* 6*d.* per ton; int. depr. and sinking fund at 12½ per cent.	.....	1.475	.811	.589	.4785	.411	.367	.336	.314	.294	.279

COMPARATIVE RATES CHARGED FOR POWER UNDER VARYING LOAD FACTORS, BY DIFFERENT ELECTRIC POWER SUPPLY AUTHORITIES.

DISCOUNTS FOR PROMPT PAYMENT NOT TAKEN INTO ACCOUNT.

Price given in Pence per B.O.T. Unit. 25 Francs = £1. 1 Dollar = 4*s*. 2*d*. 1 Rupee = 1*s*. 4*d*.

LOCATION OF SUPPLY.		LOAD FACTOR, PER CENT. 50-hp. Motor Absorbing 37,500 Watts Per Hour.									
Authority.	Method of Generation.	10	20	30	40	50	60	70	80	90	100
SWITZERLAND.		*D.*	*D.*	*D.*	*D.*	*D.*	*D.*	*D.*	*D.*	*D.*	*D.*
Beznau	Water	2.484	1.242	.828	.736	.645	.536	.463	.402	.359	.322
Rheinfelden	Water	2.486	1.243	.828	.621	.545	.485	.445	.413	.388	.37
Average of Swiss power stations (fixed rate)	Water	1.78	.89	.592	.444	.....	.....	.....	.....	.....	.....
Average of Swiss power stations (meter rate)	Water	4.27	2.13	1.42	1.065	.....	.....	.....	.....	.....	.....
CANADA.											
Hamilton	Water	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5
Montreal	Water	4.37	2.19	1.46	1.09	.875	.727	.617	.549	.486	.437
British Columbia E. P. Co., Ltd.	Water	1.06	1.03	1.026	1.019	1.014	1.012	1.01	1.008	1.006	1.004
INDIA.											
Mysore (Kolar gold fields supply 92 miles)	Water	3.66	1.83	1.22	.915	.735	.61	.524	.457	.403	.366
Mysore (Bangalore local supply)	Water	3.985	1.99	1.328	.985	.797	.664	.567	.495	.442	.398
AFRICA.											
Rand Central El. Works.	Steam	5.16	3.075	2.4	2.04	1.83	1.69	1.6	1.52	1.45	1.41
GREAT BRITAIN.											
Newcastle Electric Supply Co.	Steam	1.28	1.265	1.26	1.257	1.256	1.255	1.226	1.19	1.175	1.158
Yorkshire Electric Power Co.	Steam	2.145	1.54	1.337	1.237	1.177	1.136	1.107	1.086	1.069	1.056
Clyde Valley Electric Power Co.	Steam	2.016	1.45	1.235	1.144	1.083	1.044	1.021	1 003	.986	.967
Glasgow	Steam	1.5	1.165	1.027	.96	.915	.885	.87	.855	.845	.83
Midland Electric Corp'n.	Steam	1.5	.75	.75	.75	.75	.75	.75	.75	.75	.75
Derby & Notts E. P. Co.	Steam	1.35	1 055	.838	.728	.663	.619	.588	.564	.544	.535
London County Council (proposed charges, 1907 Bill)	Steam	2.179	1.255	.946	.792	.699	.638	.594	.561	.535	.515
Ideal steam station based on total cap. exp. of £30 per kw. of plant and distribution; coal at 8*s*. 6*d*. per ton; int. depr. and sinking fund at 12½ per cent.	Steam	1.475	.811	.589	.4785	.411	.367	.336	.314	.294	.279

EUROPE.

A = Factory power about 3,000 hours per year.
B = Power taken day and night.

		FIXED PRICE PER YEAR. Francs per H.P.	PRICE ON METER. Cents per Hour.	Min. per Year.
Kanderwerk (Hydro-electric)	A 1	245 fr.	11. cts.	110 fr.
	5	220 fr.	10.8 cts.	108 fr.
	10	210 fr.	10. cts.	100 fr.
	15	205 fr.	10. cts.	95 fr.
	20	200 fr.	15. cts.	93 fr.
	25	195 fr.	9. cts.	90 fr.
	30	190 fr.	30. cts.	85 fr.
	B	Permanent power. Increase of 30% in price. Larger amounts special prices.		

		FIXED PRICE PER YEAR. H.P.	Francs per H.P.
Beznau (Hydro-electric)	A	1	215 fr.
		5	195 fr.
		10	188 fr.
		20	180 fr.
		50	170 fr.
		100	160 fr.
	B	1	280 fr.
		10	244 fr.
		50	221 fr.
		100	208 fr.

	Hours per Year.	Per K.W. Hour.
Rathausen	200	60 cts.
(Hydro-electric)	400	45 cts.
Min. per b.h.p. year, 480 fr.	1,000	24 cts.
	2,000	16 cts.
	4,400	10 cts.
	8,800	6.5 cts.
	Permanent	6 cts.

Rheinfelden (Hydro-electric) — Fixed tax of 200 fr. for 1– 4 kw.; 185 fr. for 5– 20 kw.; 162 fr. for 21– 40 kw.; 147 fr. for 41– 80 kw.; 137 fr. for 81–160 kw.; 120 fr. for 161–300 kw. + 2 cts. per kw. hour.

AFRICA.

Rand Central (Steam) — 6*d*. per unit for 730 hours use per annum of the maximum demand and 1*d*. per unit thereafter. Special rates for use between 5.0 a.m. and 4.0 p.m. Accounts rendered monthly.

Durban (Steam) — £5 per hp. per annum up to 5 hp., £3 per hp. per annum, in each case plus 2*d*. to 1*d*. per unit; less discounts varying from 15 to 25 per cent according to consumption.

Barberton (Hydro-electric) — £44 per hp. per annum.

ASIA.

Mysore.....£10 per hp. per annum.
(Supply to Kolar gold fields, 92 miles transmission)
(Hydro-electric)

Calcutta.....4*d.* per unit less discounts
(Steam) for large quantities.

Shanghai.....2*d.* to 1½*d.* per unit.
(Steam)

AUSTRALASIA.

Waipori Falls (New Zealand)..3*d.* to ½*d.* per unit depending on load factor.
(Water)

Melbourne.....2*d.* per unit.
(Steam)

Sydney.....2*d.* per unit.
(Steam)

Redfern (New South Wales)...2½*d.* per unit.
(Steam)

Kalgoorlie.....4*d.* to 3*d.* with discounts.
(Steam)

Hawera (New Zealand).....£14 to 8*s.* 6*d.* per hp. per annum depending on load factor or by meter 3½*d.* to 4*d.* per unit.
(Hydro-electric)

Hobart.....3*d.* to 1*d.* per unit according to load factor.
(Steam)

BRITISH NORTH AMERICA.

Hamilton.....Base rate. 3 cents per hp. hour, with discounts extending to 66⅔ per cent for use of 2,900 hp. hours per month. This rate applies to motors up to 30 hp. Above 30 hp., price is 1 cent net per hp. hour; if above 50 hp., ¾ cent net per hp. hour. If the user shut off supply from 5.0 p.m. to 6.10 p.m., between October 1st and March 1st each year, minimum charge in every case is $1.20 per month per hp. of motors.
(Water and steam)

		Hours per Month.	Per K.W. Hour.
British Columbia.....	First	100 kw.	7 cents.
(Hydro-electric)	Next	50 kw.	6 cents.
Electric Railway Co.	Next	50 kw.	5 cents.
(Vancouver Power Co.)	Next	50 kw.	4 cents.
	Next	50 kw.	3 cents.
	On excess over	300 kw.	2 cents.

Montreal.....
(Water and steam)

	Per H.P. per Annum.
1– 3 hp.	$90.00
3– 5 hp.	85.00
5– 7 hp.	80.00
7– 10 hp.	75.00
10– 15 hp.	70.00
15– 25 hp.	65.00
25– 50 hp.	60.00
50– 75 hp.	55.00
75–100 hp.	50.00
100–200 hp.	40.00

Rate for large consumers, as factories, etc., range from $17.00 to $25.00 per hp. for twenty-four hours' service.

GREAT BRITAIN.

		Units per Quarter.	Per Unit.
Newcastle-upon-Tyne Electric Supply Co., Ltd.....	First	1,000	1½*d.*
Ordinary consumers	Next	50,000	1¼*d.*
(Steam)	Next	50,000	1*d.*
	All above	101,000	¾*d.*

5 per cent discount for cash. Accounts rendered quarterly. Special prices for special quantities.

	H.P. Installed.	Price per B. T. U.	Minimum No. of B. T. U's. per Quar.	Revenue per Quarter.
Midland Electric Corporation.....	40 hp.	.750*d.*	7,500 B. T. U.	£23– 8– 9
(Steam)	35 hp.	.825*d.*	6,562½ B. T. U.	22–11– 2
	30 hp.	.850*d.*	5,625 B. T. U.	19–18– 5
	25 hp.	.875*d.*	4,687 B. T. U.	17– 1–10
	20 hp.	.900*d.*	3,750 B. T. U.	14– 1– 3
	15 hp.	.950*d.*	2,812½ B. T. U.	11– 2– 8
	10 hp. and under	1*d.*	1,875 B. T. U.	7–16– 3

Accounts rendered quarterly. 3,000 hours per annum, about 33⅓ per cent load factor or alternative. At the rate of 1½*d.* for every B. T. U. supplied, subject to a discount for cash within twenty-one days.

From 10,000 to 30,000 B. T. U. per annum making a net price of 1.4*d.* per unit.
From 30,000 to 35,000 B. T. U. per annum making a net price of 1.2*d.* per unit.
From 35,000 to 40,000 B. T. U. per annum making a net price of 1.15*d.* per unit.
From 40,000 to 50,000 B. T. U. per annum making a net price of 1.1*d.* per unit.
From 50,000 to 60,000 B. T. U. per annum making a net price of 1*d.* per unit.
From 60,000 to 75,000 B. T. U. per annum making a net price of .975*d.* per unit.
From 75,000 to 100,000 B. T. U. per annum making a net price of .95*d.* per unit.
From 100,000 to 125,000 B. T. U. per annum making a net price of .925*d.* per unit.
From 125,000 to 150,000 B. T. U. per annum making a net price of .9*d.* per unit.
From 150,000 B. T. U. per annum making a net price of..... .825*d.* per unit.

Liverpool.....2*d.* for first 3,000 units per year and 1*d.* per unit after.
(Steam)

Manchester.....1½*d.* to 1*d.* per unit depending on quantity.
(Steam)

Birmingham.....2*d.* for first 300 units per year and 1½*d.* per unit after.
(Steam)

Edinburgh.....1¼*d.* per unit net.
(Steam)

Glasgow.....1½*d.* for first 1,000 hours use of maximum demand per annum, ¾*d.* after or 1*d.* per unit if no demand made during "peak load."
(Steam)

Durham Colleries Elec. Power Corp..0.55*d.* per unit plus 10 per cent for transformation up to the ordinary load factor of each 40 per cent with reduction for special supply of long-hour users.
(Steam)

Derby & Notts Electric Power Co....£3–12–0 per annum per kw. demanded plus .4*d.* per unit, accounts rendered monthly. Accounts below £5 per month ¼*d.* per unit extra. Minimum of 12*s.* per hp. per annum to be guaranteed.

Yorkshire Electric Power Co.....£3 per annum per kw. demanded, plus: Demand up to 50 kw. .85*d.* per unit.
(Steam)
50 to 150 kw. .8*d.* per unit.
150 to 250 kw. .75*d.* per unit.
250 to 350 kw. .7*d.* per unit.
350 to 450 kw. .65*d.* per unit.
450 to 550 kw. .6*d.* per unit.
550 to 650 kw. .55*d.* per unit.
650 to 750 kw. .5*d.* per unit.
750 to 850 kw. .45*d.* per unit.
850 to 950 kw. .4*d.* per unit.
10 per cent extra for transforming.

GREAT BRITAIN (Continued)

Northern Counties Electricity Supply Co., Ltd. Ordinary consumers (Steam)	For 500 units or less	2½d. per unit.
	Above 500 units, less than 1,000 units	2¼d. per unit.
	Above 1,000 units, less than 1,500 units	2d. per unit.
	Above 1,500 units, less than 2,000 units	1¾d. per unit.
	Above 2,000 units, less than 2,500 units	1½d. per unit.
	Above 2,500 units	1¼d. per unit.

5 per cent cash discount. Special prices for special quantities, such as: 1¼d. per unit less cash discount of 2½ per cent and reduction of 1-24d. (.0416d.) per unit of each 5 per cent increase in load factor above 15 per cent, with a minimum of ¾d. per unit.

	Quantities.	Multi-phase Current at any "Standard" Pressure Required by the Consumer. Per Unit.
Fife Electric Power Co. (Steam)	Under 100,000 units per annum	1½d.
	100,000 to 200,000 units per annum	1⅜d.
	200,000 to 300,000 units per annum	1¼d.
	300,000 to 500,000 units per annum	1⅛d.
	500,000 to 750,000 units per annum	1d.
	750,000 to 1,000,000 units per annum	⅞d.
	1,000,000 to 3,000,000 units per annum	¾d.

For small installations from 2½d. to 1d. per unit. Average being about 1½d.

Clyde Valley Electrical Power Co. (Steam)

HOURS RUN PER DAY.	Under 5 kw. Average Rate Per Unit in Pence.	5 to 15 kw. Average Rate Per Unit in Pence.	15 to 50 kw. Average Rate Per Unit in Pence.	50 to 100 kw. Average Rate Per Unit in Pence.	100 to 200 kw. Average Rate Per Unit in Pence.	200 to 300 kw. Average Rate Per Unit in Pence	300 kw. and Over. Average Rate Per Unit in Pence.
1	3.	3.	3.	3.	3.	3.	3.
2	2.75	2 375	2.25	2 2	2.15	2.1	2.05
3	2.167	1.883	1.783	1.733	1.683	1.633	1.583
4	1.875	1.638	1.55	1.5	1.45	1.4	1.35
5	1.7	1.49	1.41	1.36	1.31	.26	1.21
6	1.583	1.392	1.317	1.267	1.217	1.167	1.117
7	1.5	1.321	1 25	1.2	1.15	1.1	1.05
8	1.437	1 269	1.2	1.15	1.1	1.05	1.
9	1.389	1.228	1.16	1.11	1.061	1 011	.961
10	1.35	1.195	1.13	1 08	1.03	.98	.93
12	1.291	1 146	1.083	1.033	.983	.933	.883
15	1.233	1.097	1 037	.987	.937	887	837
18	1.194	1.064	1.005	.956	.906	.856	.806
24	1.146	1.023	.967	.917	.867	.817	.766

Scottish Central Electric Power Co. (Steam)	Under 100,000 units per annum	1¼d. per unit.
	100,000 to 200,000 units per annum	1 3-16d. per unit
	200,000 to 300,000 units per annum	1⅛d. per unit
	300,000 to 500,000 units per annum	1 1-16d. per unit.
	500,000 to 750,000 units per annum	1d. per unit.
	750,000 to 1,000,000 units per annum	15-16d. per unit.
	1,000,000 to 1,500,000 units per annum	⅞d. per unit
	1,500,000 to 2,000,000 units per annum	13-16d. per unit.
	2,000,000 to 3,000,000 units per annum	¾d. per unit.

A few examples are given of the actual tariffs charged by various well known undertakings.

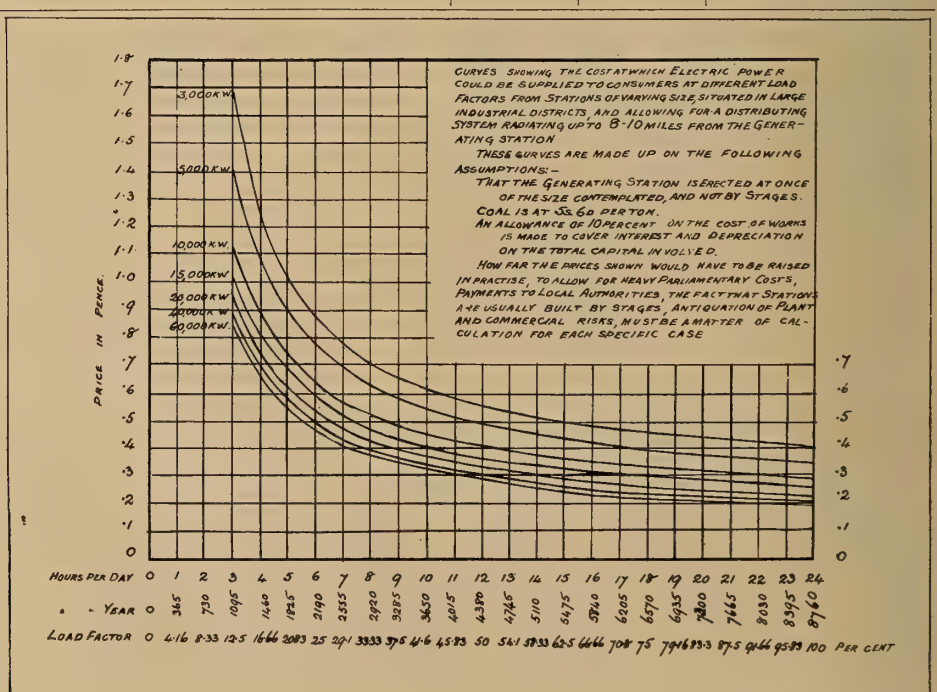
An analysis of the methods of charging for power in Great Britain shows the great discrepancy between different places. Every one aims at the 1d per unit supply or even less, but they all veil the cost in a mysterious manner in order to protect the "load factor."

Something of this sort is required to prevent the unscrupulous use of low load factor machinery, such as cranes, winches, etc.

The advantages of electric power for these operations are so well known that they are generally the first machines put into practice, and the consumer feels aggrieved if he is charged excessively for them as against what is charged for a small 5 or 10 horse-power motor running on a 25 or 30 per cent load factor.

Analysis of British Power Costs

Prices Charged.	Power Stations Owned by		Remarks.
	Local Authorities.	Companies.	
1*d.* per unit	5	3	
1½*d.* per unit	2	..	
1½*d.* to 1¼*d.* per unit	8	..	Depending on consumption.
1½*d.* per unit	12	..	
1½*d.* to 1*d.* per unit	6	..	Depending on consumption.
1¾*d.* per unit	4	1	
2*d.* and 1*d.* per unit, with varying discount	6	..	Depending on consumption.
2*d.* and 1*d.* per unit net	16	1	Depending on load factor.
2*d.* and 1½*d.* per unit net	15	2	Depending on load factor.
2*d.* and 1½*d.* per unit	3	..	Depending on load factor.
2*d.* and 1⅝*d.* per unit	2	..	Depending on load factor.
3*d.* per unit, with varying discount	3	1	Depending on consumption.
2*d.* per unit net	19	6	
2*d.* to 3*d.* per unit	..	1	Depending on consumption.
2¼*d.* to 1¼*d.* per unit	1	1	Depending on consumption.
2¼*d.* per unit net	3	..	
2½*d.* to 1*d.* per unit	7	3	Depending on load factor.
2½*d.* to 1½*d.* per unit	6	3	Depending on load factor.
2½*d.* to 1½*d.* per unit	5	..	Depending on load factor.
2½*d.* to 1¾*d.* per unit	4	..	Depending on load factor.
2½*d.* per unit, with varying discount	5	3	Depending on consumption.
2½*d.* per unit net	12	8	
3*d.* to 1*d.* per unit	5	3	Depending on load factor.
3*d.* to 1¼*d.* per unit	4	..	Depending on load factor.
3*d.* to 1½*d.* per unit	9	2	Depending on load factor.
3*d.* to 2*d.* per unit	7	2	Depending on consumption.
3*d.* per unit, with varying discount	3	..	Depending on consumption.
3*d.* per unit net	18	8	
3½*d.* to 2½*d.* per unit	1	2	Depending on consumption.
3½*d.* per unit net	1	3	
4*d.* to 1*d.* per unit	4	3	Depending on load factor.
4*d.* to 1½*d.* per unit	7	13	Depending on load factor.
4*d.* to 2*d.* per unit	1	..	Depending on consumption.
4*d.* per unit net	..	8	
4½*d.* to 1½*d.* per unit	1	8	Depending on consumption.
4½*d.* per unit net	..	2	
5*d.* to 1*d.* per unit	2	..	Depending on load factor.
Miscellaneous	11	13	
Total	218	100	


Curves showing the cost at which Electric Power could be supplied to consumers at different load factors from Stations of varying size, situated in large industrial districts, and allowing for a distributing system radiating up to 8-10 miles from the generating station
These curves are made up on the following assumptions:—
That the Generating Station is erected at once of the size contemplated, and not by stages.
Coal is at 5s. 6d. per ton.
An allowance of 10 per cent. on the cost of works is made to cover interest and depreciation on the total capital involved.
How far the prices shown would have to be raised in practise, to allow for heavy Parliamentary Costs, Payments to Local Authorities, the fact that Stations are usually built by stages, Antiquation of Plant and commercial risks, must be a matter of calculation for each specific case
3,000 KW.
5,000 KW.
10,000 KW.
15,000 KW.
30,000 KW.
40,000 KW.
60,000 KW.
Price in Pence.
Hours per day
Year
Load Factor
Per cent

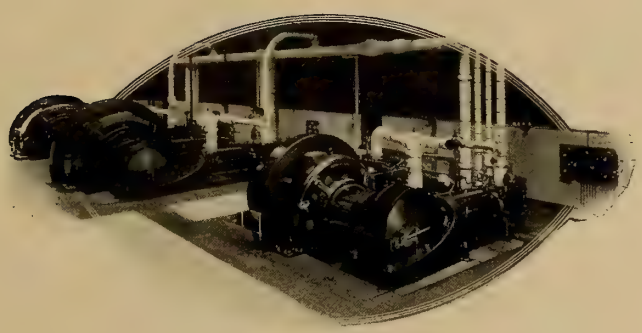
COST CURVES FOR ELECTRIC POWER

In addition to this analysis, there are no less than 130 power stations in Great Britain where the standard price is arranged to suit "load factor" and which have adopted an alternative tariff to suit the consumer who does not wish to consider his load factor.

In concluding this article it may not be out of place to refer to a curve of possible prices drawn out by Mr. G. L. Addenbrooke, during a discussion on Electrification of Collieries at the Institution of Electrical Engineers in 1906.

The curve clearly demonstrates that it is possible under the ordinary conditions required for Colliery or other power supply to give the user the benefit of low prices where good load factors are obtained.. The difficulty is to find the district which will conform to the conditions laid down and which will allow of the distribution system being dense enough to ensure economy in the distribution cables.

In the diagram a number of such curves are given, these being arranged for stations of varying sizes and for load factors from 0 to 100 per cent. They are especially intended to apply to industrial districts, and include distributions over an area of a radius of 8 to 10 miles, the minor conditions being indicated on the diagram. While such diagrams can be used only so far as the conditions of the case in hand agree with those from which the curves have been prepared, yet they offer a useful guide, and in many instances similar curves may be drawn from the data available for any special case.



SOME RECENT DEVELOPMENTS IN MACHINE TOOLS—II.

By Joseph Horner

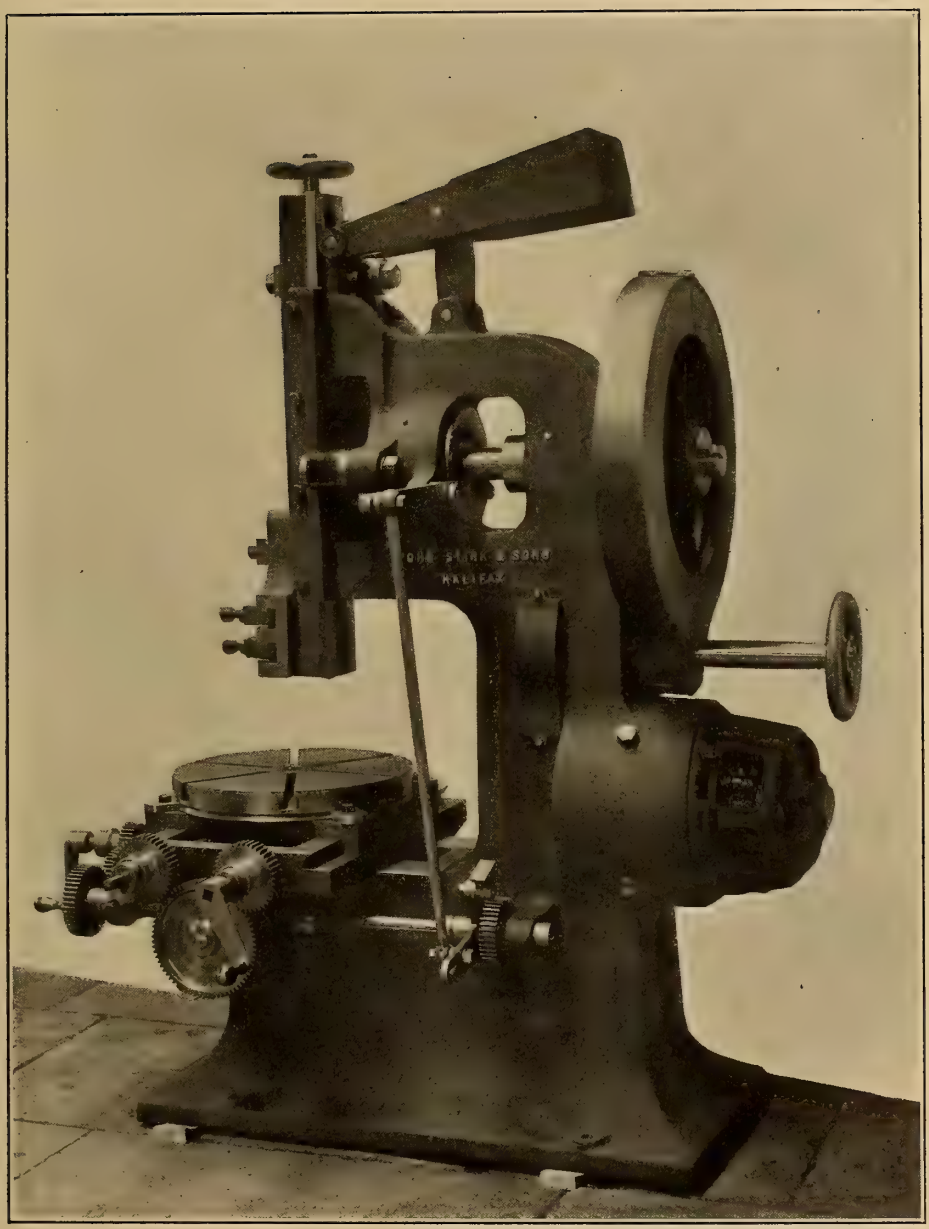
Last month some of the recent developments in the design of certain classes of machine tools were described, including gear-cutting and allied machines, milling machines for screw threads and for general work, high-speed and other lathes, high-speed planing machines and drilling machines, together with recent improvements in turret lathes and in grinding machines. The present paper, which concludes the review, discusses various miscellaneous tools, and includes among the illustrations some described in the first articles, for which room was not then available.—THE EDITOR.

A SLOTTING machine in which the head is provided with traveling motion is a novelty. One of these by the Dill Machine Company is shown in England by Messrs. Buck & Hickman, Ltd. The advantages of the traveling head need hardly be pointed out, especially when the head may be fixed rigidly in any position of overhang, or be fed horizontally after each cut. The first provides for minimum or maximum overhang for various classes of jobs, the second for feeding into work which is too massive or of too awkward a shape to be carried on the table. Half of a big fly-wheel, for example, may be blocked up on the floor for facing the boss, or for cutting the key groove. A minor but useful feature of these machines is the stroke indicator, in which a pointer moving over a dial shows the length of stroke to which the ram is set. The weight of these machines is remarkable, ranging from 10 to 12 tons in a 20-inch machine.

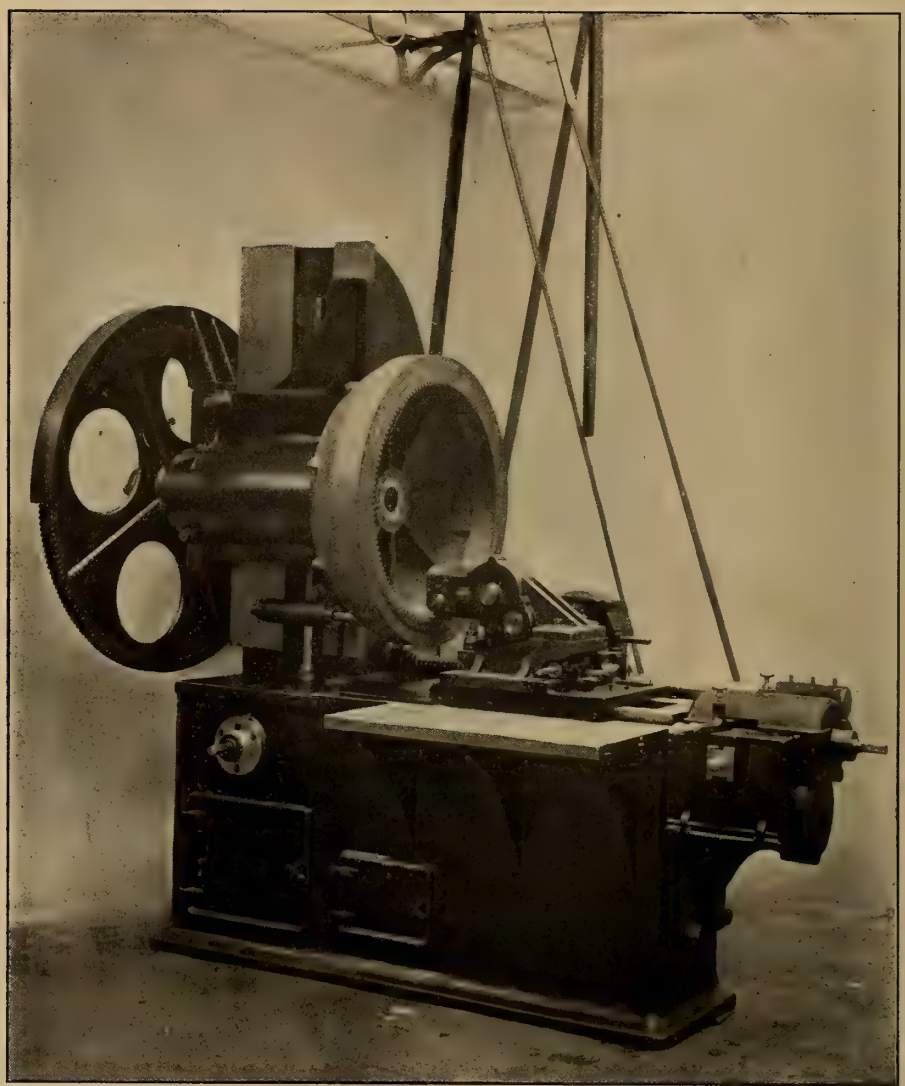
A 6-inch slotting machine by John Stirk & Sons has a novel method of driving, the motor being built into the framing at the back, so that a very snug design is obtained. The motor is wound to give 1½ H. P. at any speed between 500 and 1,500 revolutions. Power is transmitted by a chain to the pinion shaft, further reduction being given by the usual type of gearing. A purchase of about 18 to 1 is gained.

A large variety of screwing machines for bolts and nuts and for pipes are made by Joshua Heep & Co., Ltd. A notable feature of all the machines is their massive construction, the bearings and slides being liberal in extent, and provided with efficient means of take-up. Some of the hand-driven machines are fitted with squares on two of the gear spindles, the handle being placed on either, according to the power and speed required. Fast and loose pulleys are also fitted to some of these machines, to be used as an alternative to the hand gear. The largest machines are, of course, driven by power only. A releasing motion is fitted to the dies, so that they may be opened by hand or automatically at any desired point to clear the work being screwed.

A brass finisher's chasing lathe, by Selig, Sonnenthal & Co., though not a new tool, is worth noting. It is designed to avoid the changing of hobs as done in ordinary lathes, with the expenditure of time involved. The four hobs that correspond with the four standard gas threads, 11, 14, 19 and 28 threads per inch, are mounted on a disc at the rear end of the headstock, to be rotated and locked, each in position for action. The chasing bar at the rear has corresponding dies, either of which is brought into mesh with its particular hob, the others remaining idle. Then on the chasing slide there is a turret which carries four chasing tools, available for outside or inside work. These are the principal points about the lathe, though others of minor interest might be mentioned did space



SIX-INCH SLOTTING MACHINE WITH CONTAINED ELECTRIC MOTOR. JOHN STIRK & SONS, HALIFAX

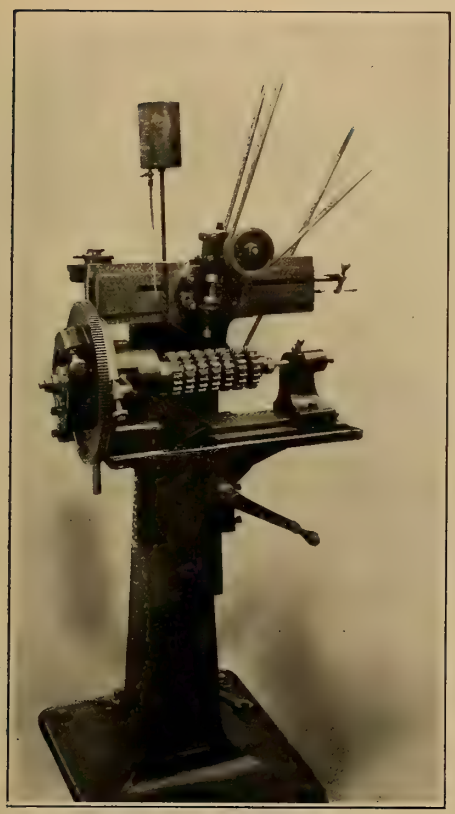


SPECIAL ATTACHMENT TO GEAR-CUTTING MACHINE FOR INTERNAL GEARS. J. E. REINECKER, CHEMNITZ-GABLENZ

permit. There is an ordinary six-slided turret with lever and screw feeds.

For those who wish to bore small cylinders in an upright drill, Messrs. Selig, Sonnenthal & Co. have a vertical drilling machine with capacity equal to cylinders of 8-inch bore in which the feed is imparted to the sliding head. The advantage of this over feeding the drill spindle after adjustment of the head is that complete support is afforded to the spindle throughout the entire length of the bore. These feeds, which are geared, can be thrown out and the spindle fed in the usual way if desired.

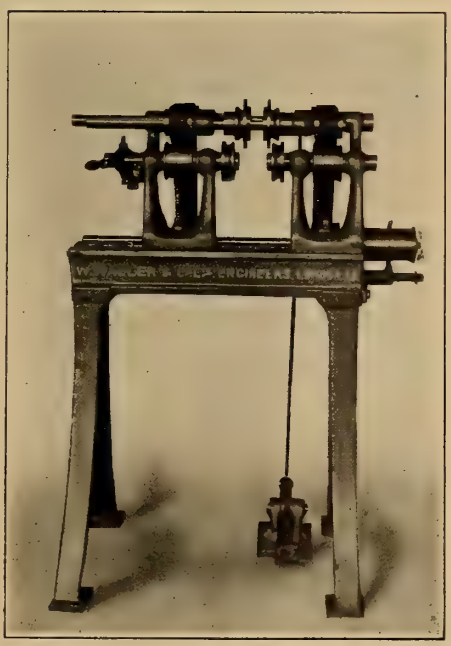
Among the machines designed for performing one operation must be included one for milling the rims of light wheels which are difficult to chuck for turning without springing them. This is made by John Hol-



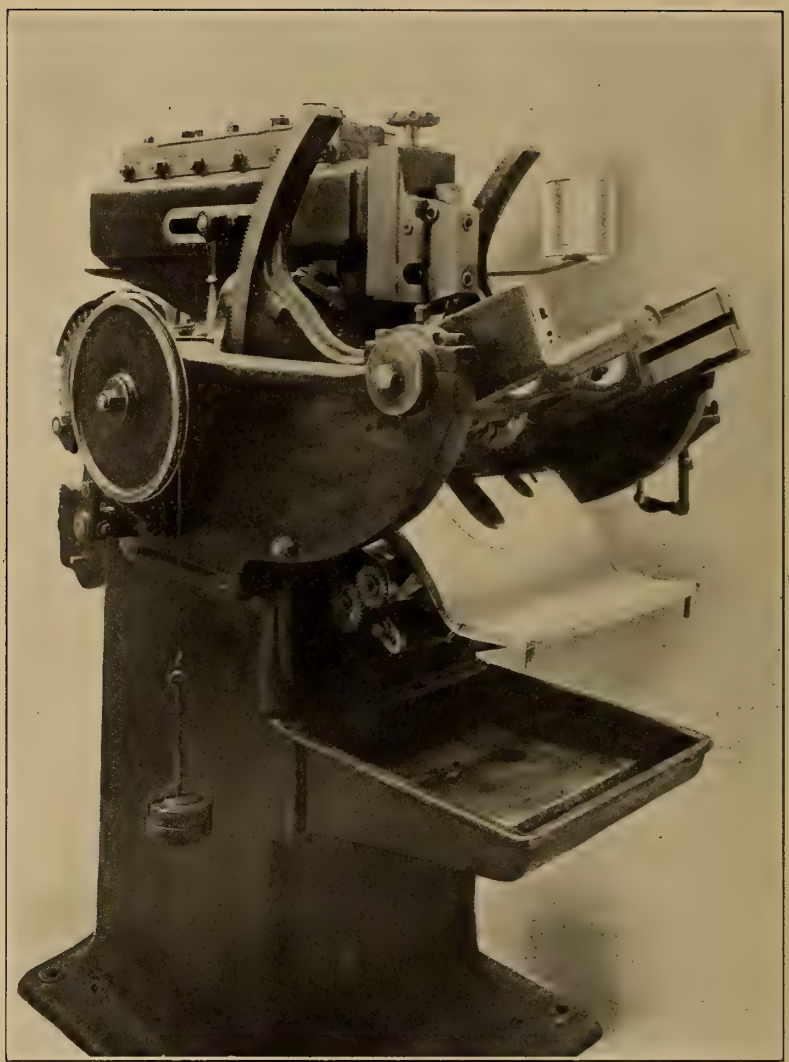
GEAR-TOOTH ROUNDING MACHINE. SCHUCHARDT & SCHUTTE

royd & Co., Ltd., and is termed a circular milling machine. Essentially it comprises two heads, one very similar to a lathe fast headstock, with three stepped cones and back gears. This rotates the milling cutter held on a mandril, fitting within the lathe mandrel at one end, and an adjustable bushed stay at the end opposite. The other head, standing parallel with the first, but adjustable in relation thereto to suit wheels of different sizes, carries and drives the work. It has a large cast-iron spindle 6 inches in diameter running in capped bearings and drives the spindle on which the work is mounted by adjustable dogs pressing against the arms on the Clement's driver principle. The other end of the work spindle is supported in a bearing. The work head can be adjusted by means of compound slides in the direction of the cutter and parallel therewith; large hand wheels and screws effecting these movements rapidly. The peripheral speed of the work can be varied from $\frac{3}{4}$ inch to 6 inches per minute. The cutter spindle, driven through back gears makes 21, 40, and 74 revolutions per minute. An automatic knock off is provided, so that when the wheel has made one revolution and a trifle beyond, the drop-worm box arrests the motion. Or the work can be rotated twice, and the knock off set to correspond.

An eight-spindle cock grinding machine by Selig, Sonnenthal, a standard tool of the firm, is a valuable time saver. It imitates the hand grinding, inasmuch as the action is that of rotation, alternating with a lift. It may be described as a turret device comprising two plates mounted on a stand, and carrying work spindles, eight in number in the machine that was shown. These spindles, revolved by pinions from a



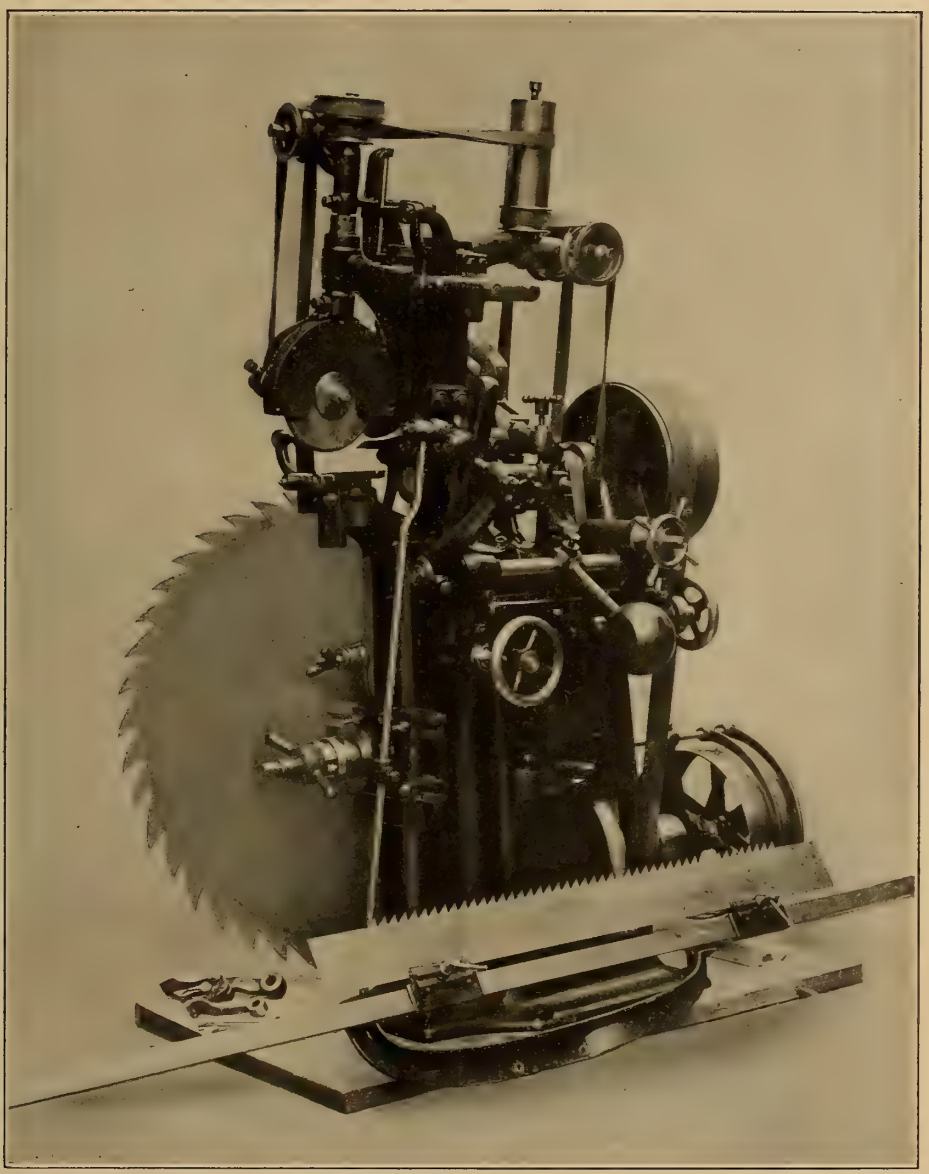
UNIVERSAL FLANGING MACHINE. W. WALLER & CO., LIMITED



OERLIKON BEVEL-GEAR PLANING MACHINE. C. W. BURTON, GRIFFITHS & CO., LONDON

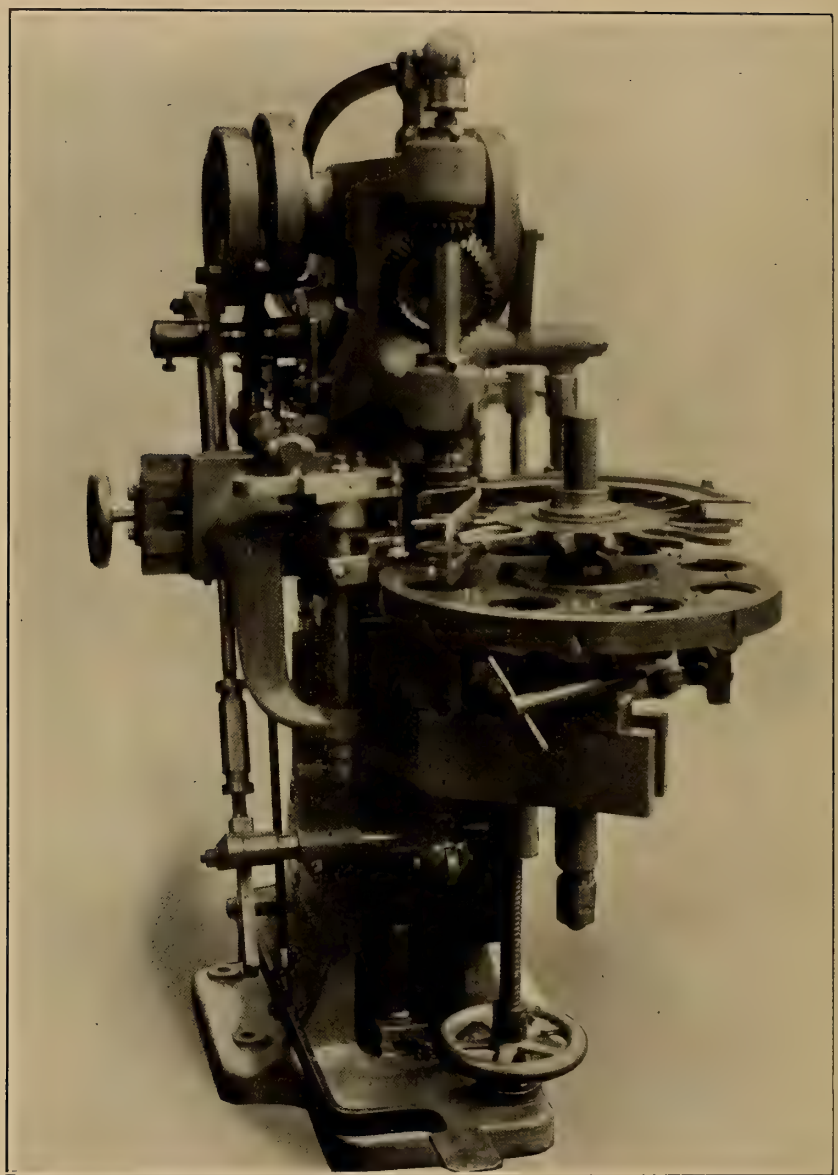
central spur wheel rotate in unison, except when any one or two are thrown out to permit the attendants to remove or replace cock plugs. The plugs are screwed on these spindles, four of which are screwed with threads of one size and four of another. The valve plugs are screwed on these, with a little emery rubbed on the plugs, and the cock bodies slipped over them. The spindles rotate the plugs in the bodies, which are prevented from rotating by stops. At brief intervals the bodies are lifted automatically, and drop again, and thus the grinding is carried on. The weight of the body is sufficient to keep it against the plug.

Presses and other special allied machinery are represented in the products of L. Schuler. To the general engineer these machines are not so familiar as the tools of the machine shop, yet they fill a large place in industry, because of the demands for cams, stamped articles, drawn ob-



SAW SHARPENING MACHINE BY FRIEDRICH SCHMALZ, GERMANY. THE AGENORIA CO., LTD., LONDON

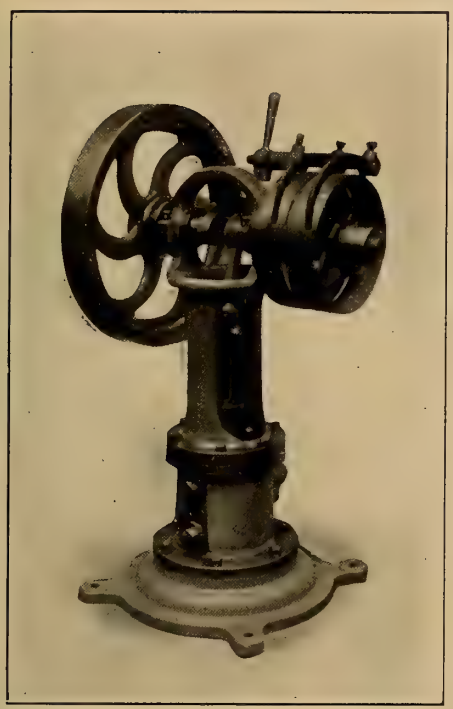
jects, as cartridge cases. Stamping, cutting, drawing, seaming, screw rolling give occasion to a large number of machines varying in design, and each design in numerous powers. The inclined power press, belt driven, running at about 60 revolutions per minute is used for cutting out the discs of metal for stamping into shapes that vary little from the flat, and for drawing deep articles. The shape in plan is produced by the discs used. For very heavy work the geared double-cranked press is preferable, due to the power gained by gearing, and the enclosed arched framing which cannot spring, as an open-sided press however strongly



AUTOMATIC SELF-FEEDING DOUBLE SEAMING MACHINE. W. WALLER & CO., LTD., LONDON

made, will do under heavy duty. The power screw press is a type which is closed and rigid, but a screw of quick pitch and treble threaded takes the place of the crank. The screw is driven by a heavy fly-wheel above, which is driven by two friction discs on the driving shaft, belted from the counter shaft. The fly-wheel rim is covered with leather. As the screw descends, the wheel is driven at larger radii on the discs so that power is applied gradually.

Another machine of Mr. Schuler is a bottom-slide drawing press, on which a bottom slide that carries the die is moved up and down, differing in this respect from the presses in



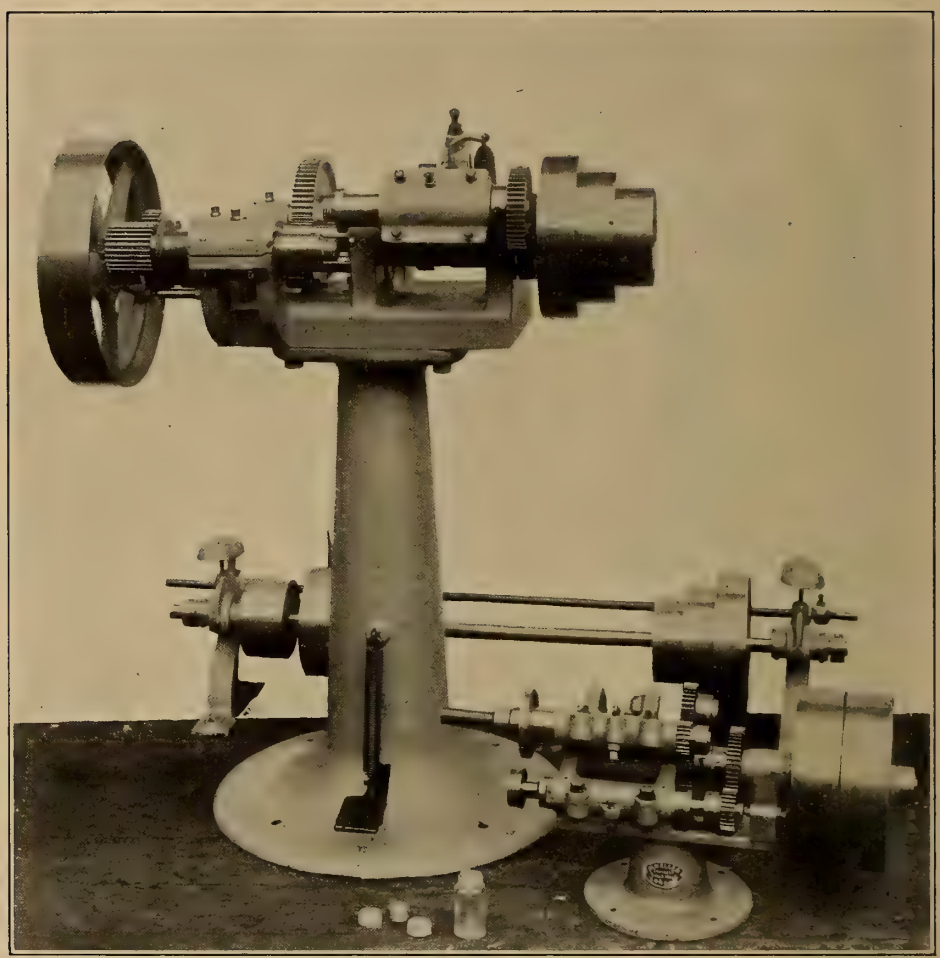
DOUBLE-ACTING VACUUM PUMP. W. WALLER & CO., LONDON

which the bed is fixed. A cam shaft and gearing impart the motion to the slide which carries the die, and the drawing punch reciprocates with the top slide. Besides machines for seaming, trimming, and beading there was a screw machine for forming the screws on incandescent lamp holders, covers for cans, and glass vessels, etc. The screw is formed by pressure between two screwed mandrels, that make about 400 revolutions per minute, the pressure and release being effested automatically. The screw rolling machines for the metal caps and stoppers of bottles turn out prodigious quantities. The screw thread, formed by pressure between screw dies has automatic cam control for pressure and release, and the output is from thirty to forty per minute, according to the size of cap. Seaming is done on shapes of cams, which are not circular, by employing a form of the required shape on the flange or nose of the vertical spindle of the machine. All discs on these machines are made in forged steel.

Messrs. W. Waller & Co., Ltd., manufacturers of machinery for sheet-metal working, make some very interesting special machines. Automatic screwing machines, presses, flanging, seaming, and double-seaming machines and a testing apparatus are of much interest. There is a self-feeding double-seaming machine for putting on the tops and bottoms of canisters. These are carried on a rotating disc, with eight holes under the tools. They are fed and removed by two attendant girls, and the astonishing output of 15,000 cans per day of 10 hours is recorded.

A testing apparatus is combined with a vacuum pump; a treadle operates the connection between the pump and the table, on which the cans to be tested are laid mouth downwards. There are two such testing areas used in order that one can shall remain under test for a short period while the other is being put in place. The vacuum is usually 23 inches, as indicated by a vacuum gauge. When the gauge needle remains fixed the tin is proved to be sound, but if not

VACUUM TESTING TABLES FOR PROVING THE TIGHTNESS OF TIN CANS. W. WALLER & CO.



AUTOMATIC MACHINE FOR MAKING SCREWED CAPS OF SHEET METAL. W. WALLER & CO., LTD., LONDON

it is condemned as faulty. To release the tin the operator has only to press his wrist on a pad adjacent which destroys the vacuum.

A universal flanging machine, flanges cans of different sizes with the same chucks, the adjustment of the rollers being operated by a treadle. A screwing machine by the same manufacturers rolls the threads on caps for bottles and other articles at the rate of thirty or forty a minute.

The foregoing is a selection only of notes and impressions. Though much has necessarily been omitted, the machines which have been described and illustrated are those which appear to the writer to best indicate the trend of present-day design.

FUEL LOSSES IN STEAM POWER PLANTS

AS INDICATED BY ACTUAL TESTS AND EXAMINATIONS.

By Geo. H. Barrus

IN a previous number of CASSIER'S MAGAZINE the writer gave an account of the principle losses to which steam plants in commercial operation are subject, and explained the methods employed in locating and measuring. The purpose of the present article is to go over the subject again and illustrate it in the more important features by examples drawn from some of the tests of steam plants which he has conducted. The order followed will be substantially the same as in the previous article, where the matter was separated into two divisions, the first relating to the "Generation of Steam" in the boiler, and the second to the "Use of Steam" by the engines, pumps, heating apparatus, etc., to which it is supplied.

GENERATION OF STEAM

1. Efficiency Referred to Heat Basis.—The efficiency obtained in practice in the operation of boiler plants may be illustrated by means of six plants referred to in Table I. This table gives the leading data and results of 24-hour tests under working conditions, made in factories where the main engines are run from 10 to 12 hours a day, and the largest share of the steam is generated and used during that time. The boilers were all hand-fired, using the spreading system, and the coals were of the semi-bituminous class. It will be observed that these are 24-hour runs, which necessarily cover the time elapsing while the fires are cleaned, or banked; and, for these reasons, they represent less favourable conditions than those usually pertaining to steam-boiler trials, that is, test-runs of comparatively short duration.

The evaporative results obtained in the six plants of Table I. range from 9.134 pounds of water per pound of dry coal to 10.966 pounds, and the efficiencies, or proportions of the heating power of the combustible absorbed by the boiler, range from 62.3 per cent. to 76 per cent. None of these represents the best economy obtainable, although the result obtained on Plant B (76 per cent.) is about as good as could be expected in view of the exigencies of ordinary work. The reasons why the remaining results fall off may be found by studying the data given in the table, and these are taken up under the headings which follow:—

2. Influence of Method of Firing and Handling Boilers.—Plant C furnishes an example of the effect which improper firing produces on the efficiency. Here, ten boilers were in active use during the day run. During the night, seven of these were banked, and the remaining three were kept in active operation. Those actively running, both day and night, carried very thick fires, the thickness for the greater part of the time being from 12 to 15 inches, and sometimes reaching 18 inches. A depth of 6 to 8 inches of good fire is ample for all practical purposes and sufficient for economical results. This was the thickness in Plants A and B, which showed the highest efficiency of all of those given in the table. Any undue thickness causes a loss from imperfect combustion of the gases, which, in that event, fail to receive a sufficient supply of oxygen. The difference in economy between the result obtained on Plant C and the

TABLE NO. 1.—TEST OF BOILER PLANT

Designation of Plant.	A.	B.	C.	D.	E.	F.
1. No. of boilers used	5	7	10	9	4	2
2. Kind	Hor. Ret. Tub.	Hor. Ret. Tub.	Hor. Ret. Tub.	Manning Vertical	Hazelton Vertical	B. & W. Water Tube
3. Rated H.P. each	143.	142.8	119.8	137.	215.	302.
4. Rated H.P. of whole number	715.	1,000.	1,198.	1,233.	860.	604.
5. Ratio of total heating surface to grate surface	44 to 1	48 to 1	48 to 1	62 to 1	44 to 1	45 to 1
6. No. boilers banked, night run	0.	7.	7.	4.	0.	2.
7. Thickness of fires	6.	8.	15.	0. to 8	0. to 8	4 to 8
8. Kind of coal	New River	New River	Geo. Creek Cumbld.	Cambria	Eureka	New River
9. B. T. U. per lb. combustible	15,143.	15,250.	15,127.	14,934.	15,125.	15,200.
10. Lbs. of coal per sq. ft. of grate per hr., day run	9.6	7.9	12.8	10.3	6.2	10.7
11. Lbs. of coal per sq. ft. of grate per hr., night run	3.41	2.2	3.3	3.1	3.4	1.2
12. Percentage of ash	7.7	8.6	11.4	13.7	10.6	6.4
13. Steam pressure	105.	101.4	96.2	139.	116.	136.
14. Flue temperature, day run	430.	409.	490.	463.	495.	446.
15. Flue temperature, night run	305.	.....	.....	.....	441.	.....
16. Average draft	0.37	0.19	0.43	0.81	0.1	0.46
17. Maximum draft	0.75	0.67	.....	.....	.....	.....
18. Percentage of rated power developed, day run	86.2	64.6	88.9	57.3	40.	64.
19. Percentage of rated power developed, night run	25.2	16.5	21.	16.1	21.9	5.6
20. Water from and at 212° per lb. of dry coal	10.695	10.966	9.393	9.132	9.493	9.134
21. Water from and at 212° per lb. of combustible	11.587	11.988	10.602	10.583	10.618	9.800
22. Efficiency based on combustible	73.8	76.	67.7	68.8	68.4	62.3

average of Plants A and B amounted to 10 per cent., and it is evident that its cause can be laid principally to the thick fires noted.

In marked contrast with the condition of the fires in Plant C are those of Plants D and E, and here are two instances where the extreme of too thin fires, carelessly allowed on portions of the grates, was the main cause in producing a corresponding loss of economy. Another unfavorable condition in these instances was that during the night period of low output, five of the nine boilers in one case were kept in operation, and the whole plant in the other case, and this resulted in carrying very slow fires. At the same time, these fires were poorly attended, and, consequently, they were run at greater disadvantage.

The unfavorable showing of Plant A, as compared with Plant B, may likewise be attributed to the effect of the night work. In Plant A the boilers were all kept in operation during the night with very slow fires, instead of the more efficient practice of banking the fires not needed, and keeping a minimum number of boilers in good active condition. In Plant B the fires were all banked by ample covering over the whole surface, and the dampers tightly closed.

Plant F furnishes another example of the effect of thickness of fires on the economy. Here, with a thickness of 4 to 8 inches, the evaporation per pound of combustible from and at 212 degrees was 9.8 pounds. On a previous test of the plant, with the same conditions, excepting the fires were less carefully attended and the thickness varied on different parts of the grates from 0. to 8 inches, the result was 8.9 pounds, or nearly 10 per cent. less.

In this connection, comparative tests on two horizontal return tubular boilers, 72 inches diameter by 15 feet long, using Pocahontas coal, one made with a thick fire and the other with a thin fire, are interesting. These are specially important because

the character of the combustion was obtained by analysis of the flue gases. The data and results are given in Table 2:—

one feature is noticeable. Of all the tests given, the ones showing the highest efficiencies are the two which have the lowest flue-temperatures.

TABLE NO. 2.—THICK AND THIN FIRES

Designation of Boiler.	G.	H.
Conditions.	Thick Fires. Depth 10 Ins.	Thin Fires. Depth 5 Ins.
1. Ratio of heating surface to grate surface	45 to 1	40 to 1
2. Percentage of ash in coal...%	6.2	6.4
3. Coal per hour per sq. ft. of grate...lbs.	20.	16.8
4. Horse power developed...H.P.	196.	200.
5. Temperature of flue gases...deg.	616.	593.
6. Force of draft...in.	.26	.32
7. Water evaporated per lb. of combustible from and at 212°...lbs.	11.56	12.15
8. Percentage of carbonic acid in flue gases...%	16.	13.7
9. Percentage of oxygen in flue gases...%	2.5	5.9
10. Percentage of carbonic oxide in flue gases...%	1.1	0.

There is ample evidence in the character of the results given in Table 2 that thick fires were detrimental. With the thick fire test the evaporation per pound of combustible was 5 per cent. less than with the thin fires, and the reason for this difference is apparent in the large amount of unconsumed gases wasted, as the analyses revealed. Although the unconsumed carbonic oxide is small, compared with the total volume of gas, being only 1.1 per cent., yet it bears a considerable proportion to the products of actual combustion (17.1 per cent.) and hence the marked influence upon the efficiency of the boiler.

An additional test made on the identical boiler "G", at slightly reduced capacity, with fires of reduced depth, gave about the same results both as to evaporation and gas analyses as those noted for boiler H.

3. Effect of High Flue-Temperature.—Although the temperature of the flue gases furnishes no exact measure of the loss in economy, where there is no knowledge of the quantity of gas escaping, it is a well recognized fact that, other things being the same, high flue-temperature indicates loss, and no illustration is needed to impress the truth of this statement. In the plants given in Table I., there is no conspicuous example of high flue-temperature, but The average temperature given for the day runs of "A" and "B" is 420 degrees, while the average for the remaining four is 473 degrees. If we compare Plants C and B again (the former having a flue-temperature of 490 degrees, and the latter 409 degrees) it is evident that the unfavorable effect of the thick fires before referred to was enhanced by the increased temperature of the flue.

One of the most conspicuous examples of loss produced by this cause, which the writer recalls, although not referred to in this table, is the case of a vertical water-tube boiler which used anthracite pea coal. This boiler was found to give the very low economy represented by 7.4 pounds of water actually evaporated per pound of dry coal. It was found that the cleaning of the boiler had been neglected, and the outside surfaces of the tubes had not been thoroughly blown for several weeks. As a consequence, the flue-temperature ranged from 700 degrees to 900 degrees Fahrenheit. The boiler was then given a thorough cleaning, and on a subsequent test the evaporation was 8.9 pounds, the flue-temperature having been brought down no less than 200 degrees. Examples of a similar kind frequently come to notice.

4. Influence of Baffling.—Plant F furnishes an instance, which goes to

show, among other things, that ineffective baffling is the cause of loss, the distribution of the hot products of combustion over the heating surfaces and the absorption of heat being incomplete. This is the case of a water-tube boiler in which the baffles consist of so-called "flame-plates," which divide the heating surfaces into three compartments, the hot gases passing through them, one after the other in succession. The area of opening for draft, measured at right angles to the course of the gases in the last compartment, is 29 per cent. of the area of grate surface. The area of opening through which the gases pass in the fire-tube boilers of Plant A is 13 per cent. of the grate surface, and in Plant B 14 per cent., and these are less than half as great proportionately as that in the water-tube boilers noted. If we take the measurement at the point where the products leave the first, instead of the last, pass, the difference is much greater.

The effect of the large draft opening in these boilers is to cause the products of combustion to take a short cut through the middle portions of the three compartments, and leave untouched the tube surfaces on the sides and in the corners. The loss of heat would be shown in this case by the excessive temperature of the flue gases, were it not that there is an unusual opportunity here for leakage of cold air into the setting and flue on account of the small side-cleaning doors and large plate iron doors at the rear, which, under the influence of a strong draft, diluted and cooled the gases. Another thing worth noting is that the loss from incomplete baffling is most marked in cases like this, where the boiler is operated at comparatively low capacity.

That this matter is one of real, and not fancied, importance, may be shown by the effect produced in a similar plant where the boilers were run at nearly the same rate of capacity. It was sought to overcome the effect of large draft area by partly covering the spaces between the tubes in the top row with brick so as to reduce the opening about 50 per cent. The temperature of the gases, with the boiler arranged in the ordinary way without the brick covering averaged for a period of 5 hours 420 degrees. After reducing the opening in the manner stated, the average for a similar period was 375 degrees, the drop due to the reduction of opening and the better distribution of the heat over the surfaces being 45 degrees.

Another instance of the effect of baffling on the flue-temperature is that of a Stirling water-tube boiler, in which the opening between the tubes was changed by increasing the height of the baffling at the top of the first bank of tubes, and baffling off and reducing the opening into the damper space through the rear bank of tubes. The former was reduced from 30 per cent. to 20 per cent. of the grate surface, and the latter from 25 per cent. to 12 per cent. of the grate surface. In the first case, with the full opening, the temperature was 552 degrees. In the second case, with the reduced opening, the temperature was 467 degrees, the reduction being 85 degrees.

5. Utilizing Waste Heat of Gases. —A large amount of data could be given showing the improvement produced by a feed-water heater in the flue, and the absorption of heat which would otherwise go up the chimney to waste. These reveal the surprising fact that a marked advantage is often secured even with a comparatively low flue-temperature. A single instance of this kind will perhaps illustrate the subject better than a large number of cases of excessively high temperature where the adaptability of a flue heater is self-evident. The case is one of an electric railway and lighting plant, having in all four water-tube boilers of the B. & W. type, with an aggregate of about 14,000 square feet of heating surface and 238 square feet of

grate surface. The flue heater, or economizer, had 4,600 square feet of surface. The draft was produced by a chimney 175 feet high. One of the boilers was out of use and shut down. In one of the boilers under steam the fire was banked for a period of 19 hours out of the 24, and the remaining two were run continuously night and day. These were never pushed hard, except at the time when the peak of the load was on, and the third boiler was brought into use. Tests of 24 hours duration were made, with and without the flue heater, using Cumberland coal, and the leading data and results are given in Table III:—

pounds, and, in the latter, 53 pounds. Taking the case of Plant H. Table II, where the analysis showed a more normal composition (13.7 per cent. CO_2, 5.9 per cent. O_2) the quantity of gas was only 18 pounds per pound of carbon.

6. Efficiency Referred to Commercial Basis.—The commercial efficiency of a boiler plant is shown by the cost of coal required to evaporate a given quantity of water, the unit of evaporation generally employed being 1,000 pounds. This matter is illustrated in Table IV., which gives the results obtained on six plants, using coal of different kinds and different costs per ton.

TABLE NO. 3.—FLUE HEATERS

Designation of Plant.	I.	J.
Conditions.	Flue Heater On.	Flue Heater Off.
1. Percentage of ash...%	8.3	7.9
2. Coal per hour per sq. ft. of grate surface...lbs.	9.7	11.2
3. Percentage of builders' rated horse power developed (average for 24 hours)...%	49.8	55.2
4. Force of draft in main flue near boilers...in	.49	.57
5. Temperature of feed water leaving pump...deg	103.	99.
6. Temperature of feed water leaving heater, or entering boilers...deg	203.	99.
7. Temperature of escaping gases leaving boilers...deg	368.	389.
8. Temperature of gases leaving heater, or entering chimney...deg.	246.	389.
9. Water evaporated per lb. of dry coal...lbs.	9.79	8.56
10. Percentage of saving due to heater...%	12.4	.....

The surprising thing about the tests given in Table III. is that a cooling of only 122 degrees in the gases secured a heating of 100 degrees in the temperature of the feed water. In view of the low specific heat of the products of combustion, this could only be explained on the ground that there was a very large excess of free air passing through, along with the gases. Analyses of the flue gases entering the economizer, which were made, revealed this very condition of things. While the boilers were most active, the analyses showed the presence of 6.7 per cent. carbonic acid, and 13.5 per cent. oxygen, and during the period when the boilers were least active, the percentages were respectively 4.6 per cent. and 15.6 per cent. In the former analysis, the amount of gas per pound of carbon works out 37

These are confined to three cases where a good quality of semi-bituminous coal was used, and three where the coal was a mixture of semi-bituminous coal and small sized anthracite coal. The first three, "B", "C" and "D", refer to the same plants as those given in Table I., many of the quantities being repeated for ready comparison. The last three, "K", "L", and "M", refer to other factory plants running in a similar manner as to the day and night output. All six examples are 24-hour tests under regular working conditions:—

The cost of evaporation in Table IV. ranges from 17.6 cents to 20 cents for the plants using clear semi-bituminous coal, and from 14.5 cents to 16.7 cents for those using a mixture of the same and low-priced anthracite. These are corrected for the

TABLE NO. 4.—TESTS OF LOW-PRICED FUELS

Designation of Plant.	B.	C.	D.	K.	L.	M.
	7. Hor Ret. Tub.	10. Hor. Ret. Tub.	9. Manning Vertical	4. Manning Vertical Fan Blast	1. B. & W. Water Tube Steam Blast	7. 4 Corliss Vertical, 3 Hor. Ret. Tub. Economizer, Ind. Draft
3. Rated H.P. each.....B.H.P.	142.8	119.8	137.	173.2	250.	175. and 113
4. Rated H.P. of whole number.....B.H.P.	1,000.	1,198.	1,233.	693.	250.	1,039.
5. No. boilers banked, night run.....	7.	7.	4.	0.	1.	6.
6. Kind of semi-bituminous.....	New River	Geo. Creek Cumbld.	Cambria	New River	New River	Geo. Creek Cumbld.
7. Cost of semi-bituminous coal per ton (2,240 lbs)...¢	4.15	4.00	3.95	3.70	3.88	4.40
8. Kind of anthracite coal.....	.....	.....	.....	No. 3 Buckwheat	Yard Screenings	Ontario & Western, No. 3 Buckwheat
9. Cost of anthracite coal per ton (2,240 lbs.).....$	.....	.....	.....	2.65	2.00	2.85
10. Proportion of anthracite coal to semi-bituminous...	0.	0.	0.	3 to 1	1.4 to 1	Equal parts
11. Percentage of ash.....%	8.6	11.4	13.7	12.2	12.5	11.6
12. Percentage of rated power developed, day run...%	64.6	88.9	57.3	88.4	92.	71.
13. Percentage of rated power developed, night run...%	16.5	21.2	16.1	34.3	1.6	11.6
14. Water evaporated from and at 212° per lb. of dry coal.....lbs.	10.695	9.393	9.493	9.427	9.529	10.336
15. Cost of coal required to evaporate 1,000 lbs. of water from and at 212°.....cents	17.6	20.	19.9	15.2	14.5	16.7

cost of the artificial draft. The averages in the first three cases are $4.03 for the cost per ton, and 19.2 cents for the cost of evaporating 1,000 pounds of water, while those for the last three are $3.99 for the cost per ton of the semi-bituminous coal; $2.50 for that of the anthracite coal, and 15.5 cents for the cost of evaporation. As the average cost of the soft coal is about the same in both cases, the average cost of evaporation can be fairly compared, and, as will be seen, they show a difference of nearly 20 per cent. in favor of the mixed fuel. This comparison is commercial in character rather than scientific, for the plants compared are not identical, nor even of the same design, as they should be for a purely scientific determination, but it may be said that, with the prices of coal given, the difference in cost of evaporation is about the same as occurs when fuels of the same character are tried in the same boiler and under equal conditions.

USE OF STEAM

7. Test of Entire Plant.—It is out of the question to summarize illustrations showing fuel losses pertaining to the use of steam for different plants, because it seldom happens that in any two plants the steam is supplied to the same number and kinds of apparatus, or employed in the same classes of work. It is proposed, therefore, to confine this part of the article to a single case, choosing a plant where the uses of steam are sufficiently varied to illustrate the leading phases of the subject.

The plant selected is one of a factory in which the nominal running time is 10 hours, but in which, like those in the examples of boiler plants already given, a considerable quantity of steam is consumed during the entire 24 hours. The boiler plant consists of seven horizontal return tubular boilers, each having a shell 72 inches diameter and 16 feet long between heads, with 134 3-inch fire tubes, the heating surface having an

area of 1,730 square feet, and the grate surface 33 square feet, with 50 per cent. air space. They are connected to a single chimney 72 inches diameter and 115 feet high. The collective area of the heating surface in the seven boilers is 11,910 square feet, and that of the grate surface 231 square feet. The draft is controlled by an automatic damper regulator, and the boilers are hand-fired.

The feed water is taken principally from a receiving tank supplied partly by cold water and partly by hot water returns from some of the heating apparatus of the factory. This is drawn from the tank by a single-acting steam pump, and discharged to the boilers through an exhaust steam feed-water heater. There is an auxiliary supply of feed water during a part of the night, furnished by a second pump which receives hot water returns from some of the heating apparatus.

Steam is used by one main engine, four auxiliary engines, four steam pumps, and various drying rooms, drying machines, presses, steam tables, heating chambers and tanks, besides the circulations in the heating system of the factory; and their principal features, so far as they concern the object of this article, are enumerated below.

The main engine consists of a pair of cylinders of the Corliss type, 28 inches diameter and 60 inches stroke. It is run three-quarters condensing, the exhaust pipe being so arranged that one whole cylinder and one end of the other cylinder exhaust into a condenser, and the single non-condensing end through a feed-water heater either to the atmosphere or to the heating system of the factory.

The condenser is of the barometric type, elevated above the engine, and the supply of water is furnished by a centrifugal pump, operated by a belt from the main engine shaft. This engine runs 10 hours per day.

Of the auxiliary engines there is a Corliss non-condensing engine 12 inches diameter, 36 inches stroke, used for driving some of the outlying machinery of the factory, which runs 16 hours per day and exhausts either to the atmosphere or to the heating system of the factory. There is a plain slide valve engine in a second outlying department of the factory, 10 inches diameter and 12 inches stroke, which runs 10 hours per day, and exhausts either to the atmosphere or to the heating system. There is a high-speed single-valve engine, connected to electric generators, used for electric lighting. This engine is 14 inches diameter and 20 inches stroke, and runs from 2 to 10 hours per day, depending on the requirements for lighting, and, like the other engines, exhausts either to the atmosphere or to the heating system. At the time of the test, the running time was 9 hours. There is also a direct-connected generator set, 8-KW. capacity, which is used only at night for about 10 hours, and this engine exhausts to waste.

The steam pumps embrace the two boiler feed pumps already referred to, one a 12-inch by 7-inch by 10-inch single, which runs 24 hours per day, and pumps water against a boiler pressure of 85 pounds, and the other a 7-inch by 5-inch by 10-inch duplex, which runs 9 hours per day against the same pressure. There is also a vacuum pump 6-inch by 10-inch by 10-inch single, used 24 hours per day keeping the exhaust piping clear of water and for draining the returns of the heating system of the factory, this being operated on the low-pressure vacuum system; and a cold water pump 8-inch by 8-inch by 10-inch single, running 10 hours per day and used for supplying water at about 15 pounds pressure for miscellaneous purposes about the factory. The exhaust steam from these pumps escapes to the air.

The miscellaneous apparatus for which live steam is used, embraces drying rooms, drying machines, and kindred apparatus, having a collective area of heating surface amounting to 2,800 square feet; steam tables,

TABLE NO. 5.—TEST OF PLANT "N"

1. Total coal, 24 hours, including 3% moisture	38,250.	lbs.
2. Dry coal, 24 hours	37,065.	lbs.
3. Percentage of ash	8.	%
4. Water evaporated, 24 hours, main supply	360,051.	lbs.
5. Water evaporated, heating chamber returns	18,077.	lbs.
6. Total water evaporated, 24 hours	378,128.	lbs.
7. Equivalent evaporation from and at 212°, 24 hours	401,626.	lbs.
8. Dry coal per hour during day run	2,591.	lbs.
9. Dry coal per hour during night run	897.	lbs.
10. Dry coal per square foot grate per hour, day run	10.0	lbs.
11. Dry coal per square foot grate per hour, night run	3.1	lbs.
12. Evaporation per hour from and at 212°, day run	28,773.	lbs.
13. Evaporation per hour from and at 212°, night run	8,136.	lbs.
14. Average boiler pressure	86.	lbs.
15. Average temperature of feed water	187.	deg.
16. Average flue temperature during day run	415.	deg.
17. Average force of draft during day run	.27	in.
18. Number of boilers banked during night run	4.	
19. Average revolutions per minute, main engine (10 hours)	59.	r. p. m
20. Average revolutions per minute, electric engine, 14″ x 20″, (9 hours)	179.	r. p. m
21. Average revolutions per minute, 12″ x 36″ Corliss engine (16 hours)	75.	r. p. m.
22. Average revolutions per minute, 10″ x 12″ engine (10 hours)	150.	r. p. m.
23. Single strokes per minute, boiler feed pump, day run	50.	
24. Single strokes per minute, boiler feed pump, night run	13.	
25. Single strokes per minute, vacuum pump (24 hours)	47.	
26. Single strokes per minute, return pump (9 hours)	20.	
27. Single strokes per minute, cold water pump (10 hours)	120.	
28. Average amperes, generator set, at 110 volts (10 hours)	35.	
29. Vacuum in main engine exhaust pipe to condenser	27.	in.
30. Mean effective pressure from indicator diagrams, main engine, average of 3 condensing ends	26.5	lbs.
31. Mean effective pressure from indicator diagrams, main engine, one non-condensing end	15.3	lbs.
32. Average mean effective pressure for whole engine	23.9	lbs.
33. Average mean effective pressure for electric engine	33.	lbs.
34. Average mean effective pressure for 12″ x 36″ engine	17.8	lbs.
35. Average mean effective pressure for 10″ x 12″ engine	25.2	lbs.
36. Indicated horse power, main engine	528.	I.H.P.
37. Indicated horse power, electric engine	92.	I.H.P.
38. Indicated horse power, 12″ x 36″ engine	27.3	I.H.P.
39. Indicated horse power, 10″ x 12″ engine	18.	I.H.P.
40. Boiler horse power developed during day run	834.	Bl.H.P.
41. Boiler horse power developed during night run	236.	Bl.H.P.
42. Percentage of rated horse power developed, day run	83.	%
43. Percentage of rated horse power developed, night run, referred to boilers not banked	55.	%
44. Water evaporated per pound of dry coal	10.2	lbs.
45. Equivalent evaporation from and at 212° per pound of dry coal	10.84	lbs.
46. Equivalent evaporation from and at 212° per pound of combustible	11.8	lbs.
47. Cost of coal at $4.50 per ton (2,240 lbs.) required to evaporate 1,000 pounds of water from and at 212°	19.1	cents

presses, etc., having about 1,400 square feet of surface, heating chambers containing about 13,000 square feet of surface, besides two small tanks, several glue kettles and some minor apparatus. The heating chambers are used 9 hours per day. A part of the balance is in use 24 hours per day, and a part 10 hours per day. Most of it is used at full boiler pressure. The returns of the heating chambers pass into a tank which is automatically emptied by one of the boiler-feed pumps. The remaining returns are controlled in part by traps, and in part by hand, there being 12 traps and 15 hand valves. Seven of the traps and two of the hand valves discharge into the feed tank. The remaining traps and valves discharge to waste.

The heating system of the factory, which contains about 14,000 square feet of surface, not including the covered mains and risers which have an additional area of about 3,100 square feet is warmed in cold weather by exhaust steam, so far as that goes during the running time, and, in the night when required, by live steam. The returns of the greater part of this system pass through thermostatic valves, and thence to the vacuum pump which discharges into the feed tank. There is about 500 square feet of surface which is drained to waste either by valves controlled by hand or through traps.

8. Main Trial of Plant "N".—To ascertain the performance of this plant, several tests were made, the first and leading trial being one of the whole plant, embracing the boilers, engines, and entire equipment, and covering the whole 24 hours of a calendar day. The data obtained embraced the total coal consumption; the quantity of ashes with-

drawn; the quantity of feed water supplied through the feed-water heater, and that pumped from the return tank of the heater chambers; the indicated horse-power of each of the engines, which was obtained from diagrams taken once every 20 minutes; the work done by the various pumps, and the output of the boilers during various periods of the run, as the different engines or departments of the work were on or off. The leading data and results of this test are given in Table V.:—

9. Separate Engine Tests, Plant "N."—The steam consumption of the individual engines was determined by separate tests, made on subsequent occasions. The method pursued in the case of the main engine was to supply that engine from four of the boilers, and all the remaining work from the other three, the piping being arranged so that the separation could be made and then measure the feed water independently for the boilers thus separated. This was followed by a leakage test with the main engine shut down, so as to correct for any steam used for other purposes than the engine itself. The method pursued with the remaining engines, so far as related to the determination of the steam consumption, was the water-glass method, and the tests were made on a holiday, so that each engine could be run separately for the length of time desired without the necessity of operating any other apparatus. The consumption found on each test was corrected for losses by leakage and otherwise, by making a similar water-glass test with the engine shut down.

The leading data and results of the engine tests are given in Table VI.:—

The economy of the engines revealed by these tests is shown by a comparison of the figures given in Line 9 (steam consumed per indicated horse-power per hour), with those which might be obtained from the same engines in first-class condition as to tightness of valves and pistons and correctness of valve setting, or which might be obtained from some other class of engine, or other means of furnishing the same power.

A standard of performance for an engine like the main engine, working under best conditions, with three ends condensing and one end non-condensing is 19 pounds of steam per indicated horse-power per hour, and this is about 10 per cent. less than 21.4 pounds, that actually found. The standard noted is the performance of an engine carrying an economical load, whereas, in the present case, the engine was somewhat under-loaded. To this condition might be attributed the excessive consumption, were it not that on examination of the valves and pistons for leakage, it was found that two of the valves were leaking quite a large amount of steam, one being an exhaust valve on one cylinder, and the other likewise an exhaust valve on the other cylinder.

TABLE NO. 6.—ENGINE TESTS—PLANT "N"

Designation of Engine.	Main Engine, Pair 28″ x 60″.	Electric Engine, 14″ x 20″.	Corliss Engine, 12″ x 36″.	Slide Valve Engine, 10″ x 12″.
1. Feed water consumed per hour.....lbs	12,151.	9,037.	1,636.	1,786.
2. Leakage and other losses from boilers per hour..lbs	460.	1,659.	616.	616.
3. Net steam consumed by engine per hour.....lbs	11,691.	7,378.	1,025.	1,170.
4. Average pressure by engine room gauge.....lbs	85.	84.	83.	84.
5. Average vacuum in exhaust pipe to condenser..in	27.	.....	.....	.....
6. Average mean effective pressure.....lbs	24.6*	31.6	15.4	25.2
7. Average revolutions per minute..... r. p. m.	59.	174.	75.	153.
8. I.H.P. developed.....I.H.P.	545.2	85.1	25.2	18.0
9. Steam consumed per I.H.P. per hour.....lbs.	21.4	86.8	40.5	65.
10. Dry coal consumed per I.H.P. per hour, based on boiler evaporation.....lbs.	2.1	8.5	4.0	6.4
11. Average steam accounted for by indicator at cut-off.....lbs.	16.1	21.5	22.5	41.5
12. Proportion of steam actually used, accounted for by indicator.....lbs.	.75	.25	.55	.64

* 3 ends condensing, 1 end non-condensing.

Probably one pound of steam per indicated horse-power per hour is not too much to allow for this leakage, and this is about 5 per cent. of the observed consumption.

The next question regarding the economy of the main engine relates to the advantage of operating it with one end non-condensing. The object of this system of operation is to provide for heating the feed water and any other apparatus available, by the use of exhaust steam. It can readily be estimated that, to obtain an average consumption of 21.4 pounds, the three condensing ends would use something like 19.7 pounds of steam per indicated horse-power per hour, and the single non-condensing end, 30 pounds. If the engine were run all condensing, the consumption would therefore be about 19.7 pounds, or 8 per cent. less than that found for the existing conditions. If the initial temperature of the water were 100 degrees, and it were heated by the non-condensing end to 200 degrees, the improved evaporative efficiency applied to the water required for the engine steam would just about make up for the increased steam consumption, so that the amount of coal burned would be practically the same in both cases. If, beyond this, the exhaust steam were used, not only for heating the feed water required for the main engine, but the water required for other work so far as it would go, there would be a proportionate gain in favor of running the engine with only three ends condensing.

Another question is the improvement that might be secured if the engine were replaced by one of more economical type, say a cross-compound, the boiler pressure being increased to 125 pounds. This improvement could be affected by simply changing the cylinders of the engine to those properly proportioned and arranged for compound work. Referring the matter to the case of the engine running all condensing and using 18.7 pounds of steam per indicated horse-power per hour, the engine being assumed to be in good condition, a compound engine equally economical for its class would use 13 pounds of steam per indicated horse-power per hour, and this is about 30 per cent. below the figure given for the simple engine. Viewed from the commercial standpoint, a 30 per cent. saving, with coal at $4.50 per ton, represents a reduction in fuel cost of nearly $2,000 per year.

Passing now to the auxiliary engines referred to in Table VI., the electric engine used 86.8 pounds of steam per indicated horse-power per hour, which is an enormous consumption for an automatic cut-off non-condensing engine. Although engines of the single valve class, of which this is a type, are less economical than the Corliss engine, they do not use, when in good condition, more than 32 pounds of steam per indicated horse-power per hour. Compared with that quantity there was a waste of 170 per cent. An investigation showed that this waste was due merely to leakage of the valve which had become disordered by long use.

The 12-inch by 36-inch engine was somewhat wasteful, this result being due partly to the light load, and partly to leakage of one of the steam valves, which was found in bad condition. The 10-inch by 12-inch slide-valve engine was also wasteful, but here the cause lay mainly in the type of engine rather than in its condition. The diagrams showed steam following about seven-eighths of the stroke, with a low initial pressure, such as engines of this class always exhibit.

By a simple rearrangement of the plant and the adoption of rope-driving, which would be comparatively inexpensive to install, the work done by these three auxiliary engines during the 10 hours that the main engine was in operation could have been furnished from that central source of power at a large reduction in fuel cost.

10. Steam Pump Tests, Plant "N."—Two of the pumps were tested by the water-glass method, and two by condensing the exhaust steam in a barrel of water on scales. The results of the tests, expressed in pounds of steam consumed per hour, are as follows:—

TABLE NO. 7.—SUMMARY OF LOSSES, PLANT "N," EXPRESSED IN COAL CONSUMED PER DAY

1. Main feed pump, 12″ x 7″ x 10″, 52 single strokes per minute	710. lb. per hour
2. Return pump, 7″ x 5″ x 10″ duplex, 20 single strokes per minute	210. lb. per hour
3. Vacuum pump, 6″ x 10″ x 10″, 47 single strokes per minute	280. lb. per hour
4. Cold water pump, 8″ x 8″ x 10″, 120 single strokes per minute	420. lb. per hour

The ecomomy of these pumps can best be measured by a comparison with the quantity of steam required to do the same work when power pumps are used, and they are operated by the main engine, or with the quantity required when better means of doing their work can be employed. In these instances the main foiler reed pump and the cold water pump could have been operated with power supplied by the main engine during running time, while the return pump could have been dispensed with. The saving made by so doing, assuming the main engine were compounded, would be over 100 tons of coal per year.

11. Miscellaneous Tests, Plant "N."—Among the special miscellaneous tests, that of the steam used by the heating chambers was made by supplying them from separate boilers for which the feed water was measured, and subsequently correcting the total quantity for the steam used for some minor purposes, obtained after the steam supplied to the chambers had been shut off. The chambers in use contained about 12,000 square feet of heating surface, and the temperature was gradually raised, during the nine hours that steam was on, from 70 degrees to 240 degrees, the chambers being closed and the air within having little opportunity for circulation, or ventilation. The consumption of steam was at the rate of 3,250 pounds per hour, and of this about 2,000 pounds per hour found its way in the shape of condensed water to the return pump.

The remaining miscellaneous tests were made by the water-glass method. These embraced a test of the direct-connected generator set, which consumed 375 pounds of steam per hour when generating 35 amperes of current at 110 volts; a test of drying rooms containing 2,100 square feet of radiating surface, which used 1,110 pounds of steam per hour; and a test of the leakage of stop valves attached to the system of live steam mains, including condensation in the mains, which consumed 1,505 pounds of steam per hour. As regards the latter, the steam mains, which were well covered, had an area of about 2,510 square feet of surface, and the amount of condensation here is estimated at 502 pounds per hour, leaving 1,003 pounds per hour for leakage alone. If this leakage were going on continuously night and day, it would represent a loss of about one ton of coal per day. Half of the time much of the leakage is eliminated by the use of the apparatus and the actual loss from this cause is probably half a ton a day or about 175 tons per year.

12. Coal Distribution, Plant "N."—Using the data obtained on the various analytical tests which have been described, and other data found by comparing the output of the boilers at different times as the work changed, we are now in a position to make a summary showing the distribution of the coal consumption amongst the various engines, pumps, and other departments of the work during the main test, which is given in Table 8.

13. Summary of Losses, Plant "N."—The various losses going on in

TABLE NO. 8.—DISTRIBUTION OF COAL CONSUMPTION. TEST OF PLANT "N"

1. Main engine, 528 I.H.P. at 2.1 lbs. per I.H.P. per hour (10 hours)	11,088.	lbs.
2. Electric engine, 92 I.H.P. at 8.5 lbs. per I.H.P. per hour (9 hours)	7,038.	lbs.
3. 12″ x 36″ engine, 27.3 I.H.P. at 4.0 lbs. per I.H.P. per hour (16 hours)	1,747.	lbs.
4. 10″ x 12″ engine, 18 I.H.P. at 6.4 lbs. per I.H.P. per hour (10 hours)	1,152.	lbs.
5. Main feed pump, day run, 50 single strokes per minute (10 hours)	669.	lbs.
6. Main feed pump, night run, 13 single strokes per minute (14 hours)	385.	lbs.
7. Return pump, 20 single strokes per minute (9 hours)	185.	lbs.
8. Vacuum pump, 47 single strokes per minute (24 hours)	660.	lbs.
9. Cold water pump, 120 single strokes per minute (10 hours)	425.	lbs.
10. Generator set, 35 amperes, (10 hours)	374.	lbs.
11 Heating chambers (9 hours)	2,867.	lbs.
12. Drying rooms (24 hours)	2,784.	lbs.
13. Heating factory (24 hours)	870.	lbs.
14. Heating factory, extra from 4 a.m. to 7 p.m.	1,125.	lbs.
15. Steam tables, presses, etc. (10 hours)	1,442.	lbs.
16. Miscellaneous apparatus, day run	952.	lbs.
17. Miscellaneous apparatus, night run	612.	lbs.
18. Condensation in mains (24 hours)	1,176.	lbs.
19. Leakage (12 hours)	1,120.	lbs.
20. Balance unaccounted for	394.	lbs.
Total	37,065.	lbs.
1. Four engines, referred to compound condensing type, during 10 hours running time, less extra coal required for heating in place of exhaust steam	9,311.	lbs.
2. Two steam pumps during running time	795.	lbs.
3. Return pump and heating chambers	573.	lbs.
4. Steam tables, presses and miscellaneous apparatus, from wasted drips and returns	691.	lbs.
5. Leakage of plant	840.	lbs.
Total	12,120.	lbs.

Plant N, which have thus far been considered, are summarized in Table 8. Besides those of the engines and pumps, which are based directly on the tests referred to, there are losses due to escape of steam through traps and hand-controlled drain valves, as also the loss of hot water returns and exhaust steam from various points which escaped unutilized. These losses, which are estimated partly by calculation from the data available, and partly from the results of observation, are included in the table.

Out of the total consumption of coal, 37,065 pounds, it appears from this summary that 12,120 pounds, or about one-third, may be considered as thrown away, provided the plant were arranged in a manner to utilize all the steam to the best advantage. This is 5.4 tons of coal per day, which, at the price which prevailed, —viz., $4.50 per ton—represents an annual loss of about $7,500.

If it be held that, in making improvements in a steam plant an investment is warranted when it produces sufficient ecomomy to pay for itself in four years, this sum would justify an expenditure of $30,000.

SAFETY APPLIANCES IN THE ENGINE ROOM

By William Wallace Christie

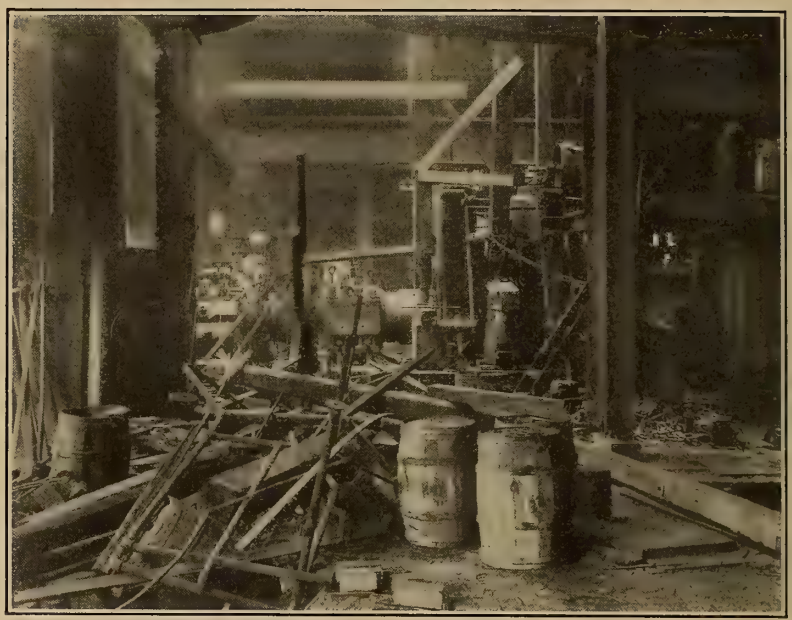
IT is generally realized that the increasing use of all kinds of power machinery has brought with it an increased number and variety of dangers. Some of these cannot be altogether prevented, but can be minimized by care in construction and operation; others require the use of auxiliary apparatus for the protection of the operatives and others in the vicinity. Thus, very early in the use of steam the safety valve was devised to prevent the accumulation of excessive pressure in the boiler, while later inventions have sought to provide against the dangers due to low water.

In the case of the boiler, however, the greatest protection has been such improvements in material, design, and methods of construction, such as to render explosions far less frequent than formerly. An important factor in this development has undoubtedly been the extension of careful systems of periodic inspection, both as a consequence of legislative enactment, and in connection with the work of insurance companies.

In the engine room, however, there are dangers which may, under certain conditions, become fully as great as with the boiler. Heavy loads, together with high rotative speeds, defective transmissions, imperfect regulating devices, etc., may introduce centrifugal forces practically as great and as uncontrollable as those released in a boiler explosion, and the damage which may be produced by the bursting of fly-wheels may be as serious as those which occur when a steam boiler explodes. That fly-wheel explosions are a real and serious menace in manufacturing communities is evident when it is realized that at the present time such disasters outnumber boiler explosions four to one, while the serious nature of the consequences may be seen by an examination of the illustrations which are here given.

The magnitude of the stresses which exist in the arms and rims of engine fly-wheels appears from the investigations of Professor C. H. Benjamin, a detailed account of which will be found in the Transactions of the American Society of Mechanical Engineers in 1898 and in 1901.

Professor Benjamin made a number of experiments upon small cast-iron wheels, pushing the rotative speed up until the wheels burst, the motive power being obtained from a Dow steam turbine, and the wheels themselves being copies, on the smaller scale of 15 to 24 inches diameter, of actual fly-wheels made by engine builders. The rotative speeds were determined by the musical note emitted by an electric vibrator as compared with standard tuning forks, so that the data were readily and accurately measured. Tests of the material used showed it to have a tensile strength of about 19,000 pounds per square inch, and the computed tension at which solid wheels broke agreed very fairly with this deter-



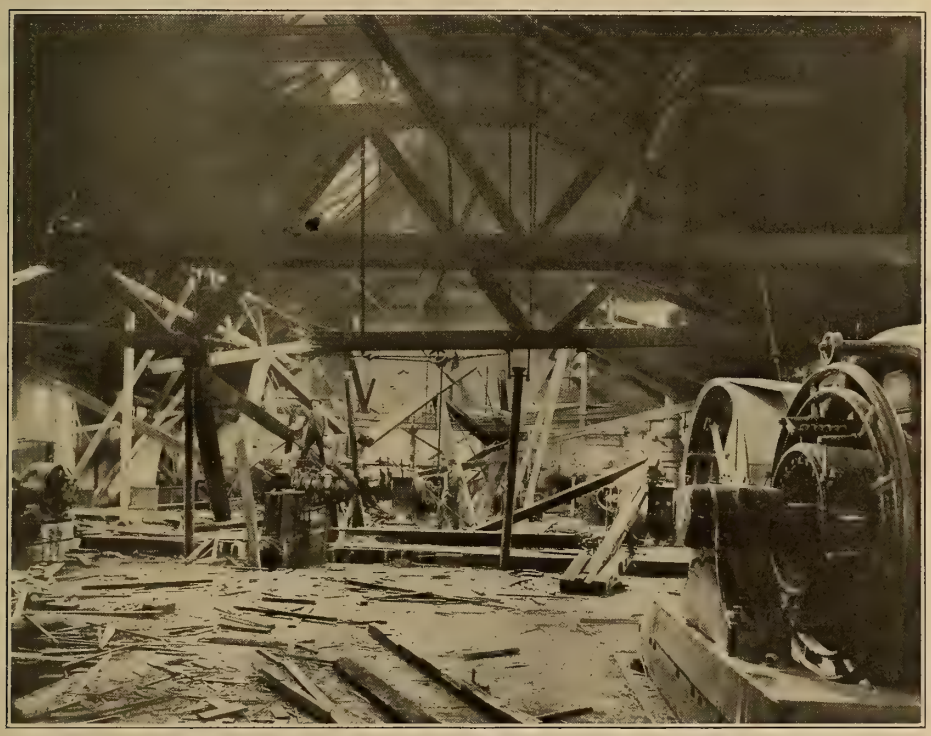
DAMAGE BY FLY-WHEEL EXPLOSION AT THE OTIS STEEL COMPANY, CLEVELAND, OHIO

OTIS STEEL COMPANY, CLEVELAND, OHIO. WRECK CAUSED BY BURSTING FLY-WHEEL

mination. In general, the explosion of these experimental wheels occured at rotative speeds corresponding to linear velocities of 350 to 400 feet per second at the rim, and Professor Benjamin states that he believes a linear rim-speed of 100 feet per second to be a safe upper limit in practice.

Experiments made upon wheels in halves showed the weakening effect and some of his conclusions are here given.

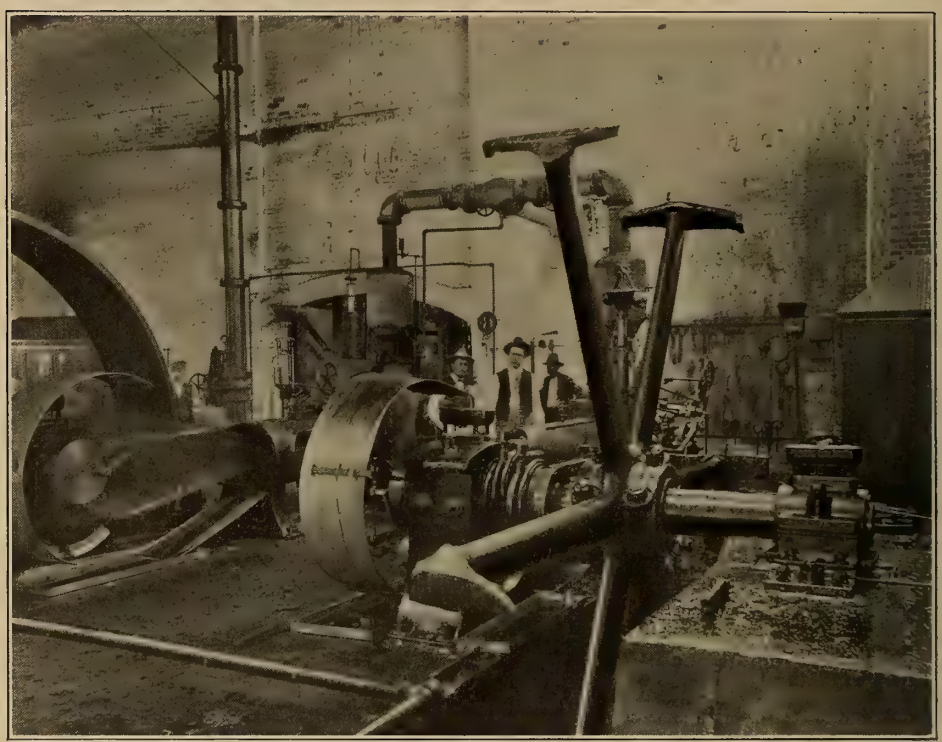
In the first place the ordinary engine fly-wheel operates, in current practice, with rim speeds approximating a mile a minute, the speed of an express railway train, and in many instances this speed is exceeded. Fracture, under such conditions, releases the fragments at velocities which carry destruction in



WRECK CAUSED BY FLY-WHEEL EXPLOSION AT THE PLANT OF THE MANSFIELD RAILWAY, LIGHT AND POWER COMPANY, MANSFIELD, OHIO

of joints. The ordinary flange joint gave way at about one-fourth the tension at which the solid wheel broke, this corresponding to about one-half the rotative speed, while the link joint was stronger, breaking at tensions ranging about 60 per cent. of those required for the solid rims. Mr. William H. Boehm, superintendent of the department of fly-wheel insurance of the Fidelity & Casualty Company, of New York, has investigated very fully the question of the explosion of fly-wheels, their path, a path which may be in any direction in the plane of rotation of the wheel. Pieces are thrown across a building, or up through the roof, or dig their way deep into the ground.

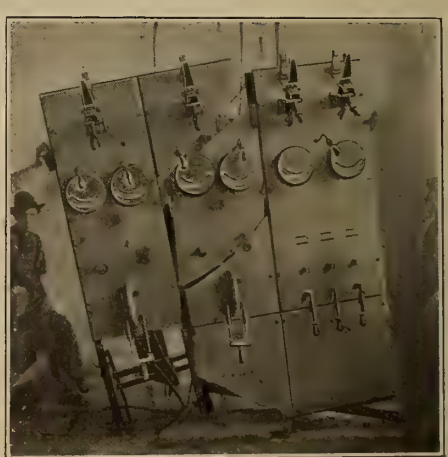
A fly-wheel explosion has been likened to a boiler explosion, but there is an important difference, and one which is not always appreciated. It is true that the centrifugal force generates a radial tension in a fly-wheel just as the internal steam pressure exerts a radial tension in a



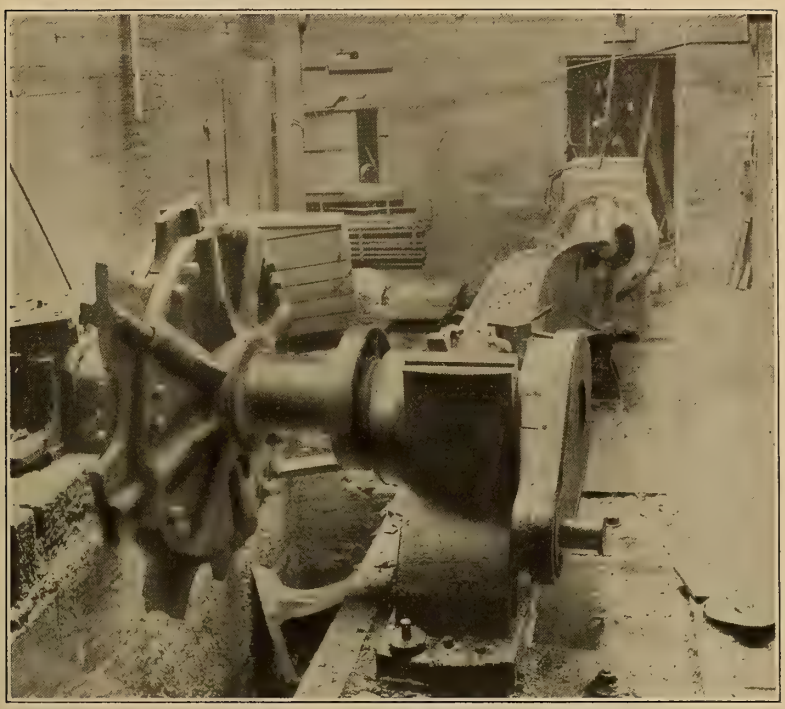
FLY-WHEEL WRECK, MUSKOGEE GAS AND ELECTRIC COMPANY

boiler, but in the case of the boiler this tension is directly proportional to the steam pressure, so that if the steam pressure is doubled, for instance, the stress on the material is also doubled, or if the pressure is trebled the stress is increased threefold. In the case of the fly-wheel, however, the centrifugal force varies as the square of the number of revolutions, so that if the rotative speed is doubled the stresses in the material are increased four times, while for a threefold speed a ninefold stress is produced.

Again, in the case of the boiler, provision against increased pressure may be made, within certain limits, by an increase in the amount of material, a thicker shell being capable of resisting an increased pressure. With the fly-wheel, however, no such method of strengthening can be employed, since any weight of material added to increase the strength of the rim of the wheel increases the centrifugal force in exactly the same proportion, and the only way to resist the stress is by the use of such materials as have the highest strength possible in proportion to their weight.



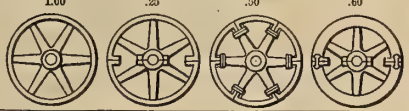
DAMAGE TO SWITCHBOARD AT MUSKOGEE ELECTRIC COMPANY



RESULT OF FLY-WHEEL EXPLOSION AT THE WORKS OF THE TENNESSEE FIBRE COMPANY, MEMPHIS, TENNESSEE

It is not intended to discuss the principles of fly-wheel construction in detail at this time, but some of the points made by Mr. Boehm may be noted. In general, for cast-iron wheels made in one piece, and carefully cooled so as to be fairly free from shrinkage strains, rim speeds of 100 feet per second may be used with safety, this corresponding to a linear velocity of about 1.15 miles per minute. The strength of the rim is materially reduced by the introduction of joints, but as such joints are necessary in the construction of wheels above about 8 feet in diameter, they must be taken into consideration. Mr. Boehm considers that the ordinary flange joint, such as is frequently employed on wheels made in halves gives a rim strength of only 25 per cent. of the solid rim, while by using the so-called pad joint an efficiency of 50 per cent. is obtained, and with the link joint an efficiency of 60 per cent.

The annexed table has been computed by Mr. Boehm, this giving the

Type of Wheels and maximum obtainable efficiency of rim-joint.				
	No joint. 1.00	Flange joint. .25	Pad joint. .50	Link joint. .60
				
Diam. in Ft.	R. P. M.	R. P. M.	R. P. M.	R. P. M.
1.	1910	955	1350	1480
2.	955	478	675	740
3.	637	318	450	493
4.	478	239	338	370
5.	382	191	270	296
6.	318	159	225	247
7.	273	136	193	212
8.	239	119	169	185
9.	212	106	150	164
10.	191	96	135	148
11.	174	87	123	135
12.	159	80	113	124
13.	147	73	104	114
14.	136	68	96	106
15.	128	64	90	99
16.	120	60	84	92
17.	112	56	79	87
18.	106	53	75	82
19.	100	50	71	78
20.	95	48	68	74
21.	91	46	65	70
22.	87	44	62	67
23.	84	42	59	64
24.	80	40	56	62
25.	76	38	54	59
26.	74	37	52	57
27.	71	35	50	55
28.	68	34	48	53
29.	66	33	47	51
30.	64	32	45	49

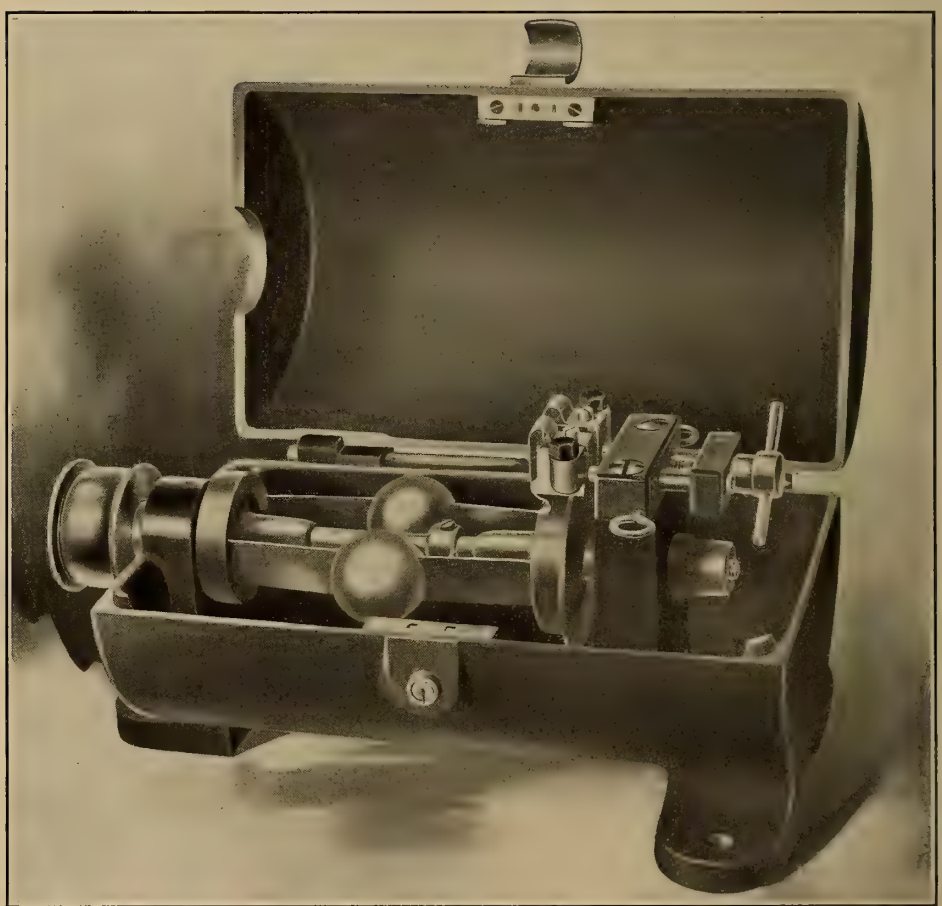
SAFE SPEEDS FOR CAST-IRON FLY-WHEELS

safe speeds in revolutions per minute for various kinds of cast-iron fly-wheels, on the basis of a margin of safety of three, for the different diameters listed.

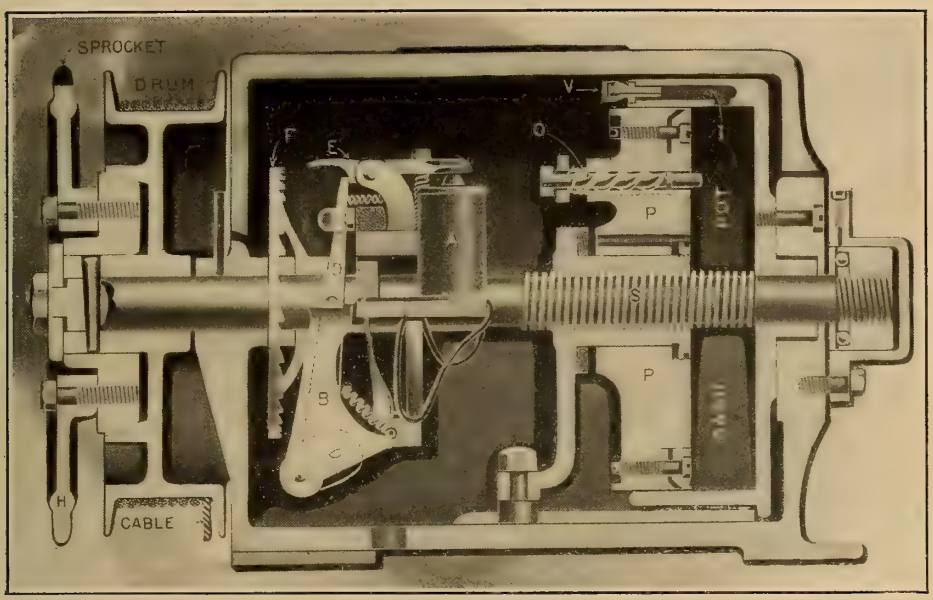
It must be remembered, however, that fly-wheels rarely burst when running at their regular operative speeds. Explosions occur when, for any reason, the speed is suddenly increased. Such increases in speed are brought about by various causes, among which the principal are the breaking of the main belt, the breaking or slipping of the governor belt at the time of sudden change of load, the loosening of the governor pulley or the sticking of the governor itself, etc., but the principal cause is the failure of the main transmission, such as the breaking of the main belt or rope transmission, suddenly throwing the load off the engine, followed by the failure of the governor to act.

Notwithstanding all the care which may have been taken in the design and construction of a power plant, there are causes for engine runaway accidents which it is practically impossible to foresee. Among these may be mentioned the case of the slipping of a governor belt as a result of the breakage of sprinkler pipes overhead, causing the watering of the belt, followed by a runaway.

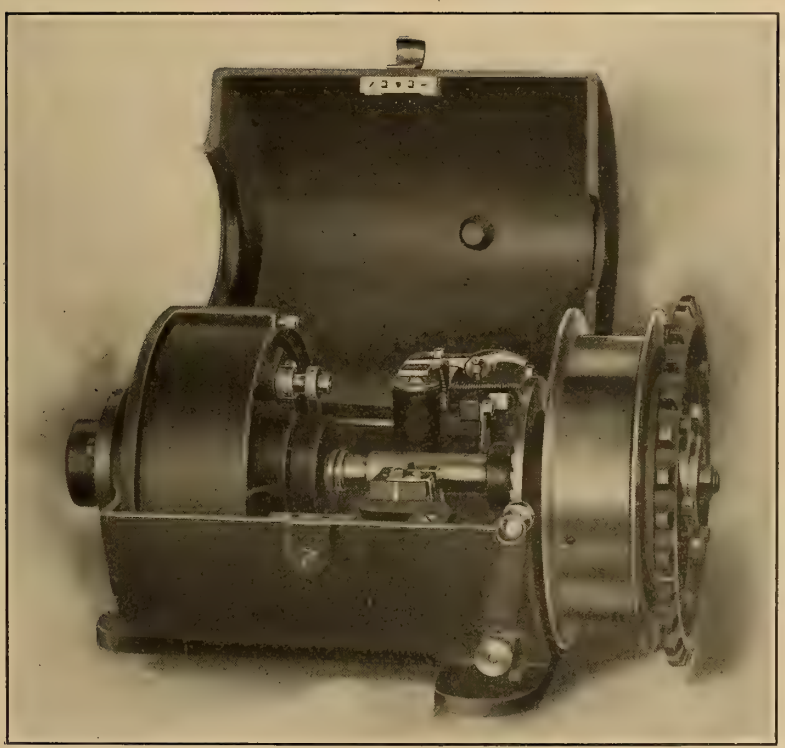
In some engines the governor is



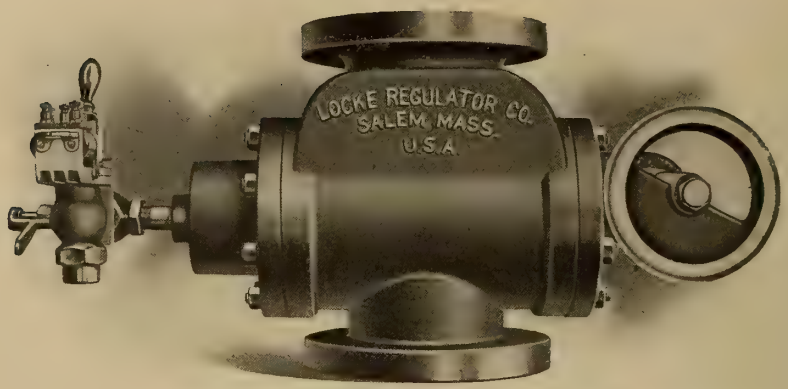
SPEED-LIMIT DEVICE FOR THE CONTROL OF THE MONARCH SAFETY STOP



INTERIOR OF MONARCH SAFETY STOP. THE ELECTRO-MAGNET RELEASES THE CATCH WHEN THE SPEED LIMIT ACTS



GENERAL VIEW OF MONARCH SAFETY STOP

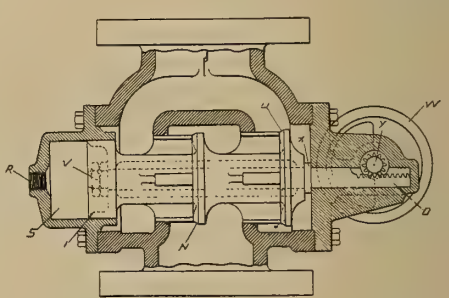


THE MAIN VALVE OF THE LOCKE SYSTEM THROWN BY STEAM PRESSURE CONTROLLED BY THE AUXILIARY ELECTRIC VALVE

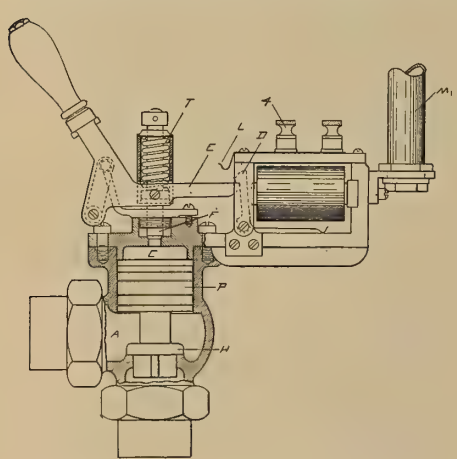
provided with a safety device, and such devices have been rendered inoperative by the engineer who, to save the annoyance of setting the device before starting the engine, wedges the governor so as to prevent its shutting down.

The special safety appliances for use in the engine room include several types, some of these simply providing an independent method of enabling the engineer to stop the engine without exposing himself to the danger of close approach. The devices are usually capable of extension to various parts of the works, so that the engine can be stopped immediately in case of the entanglement of an operative in the machinery in any room. Another group includes the so-called speed-limit devices, these being intended to throw into action an engine-stop as soon as the rotative speed of the fly-wheel shaft exceeds an predetermined limit.

One old and thoroughly tried form of safety stop is placed directly above



SECTION OF LOCKE MAIN SHUT-OFF VALVE



SECTION OF LOCKE AUXILIARY ELECTRIC VALVE

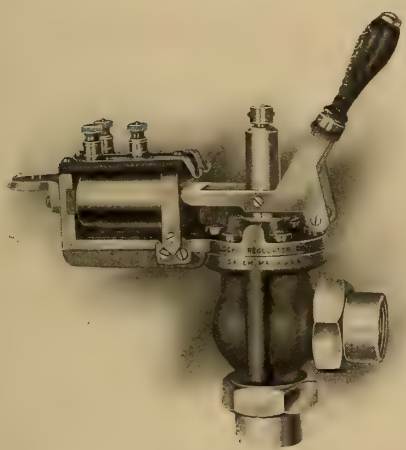
the main throttle valve, between the valve and the separator, this being electrically equipped so as to be operated from any part of the building. In such devices the speed-limit device, usually acting on the principle of a centrifugal governor, is placed near the main shaft, and directly connected with it, this making an electrical contact when the pre-determined speed is reached, throwing the stop into action. The illustrations show the action of these devices very clearly.

An important element in connec-

THE LOCKE SPEED LIMIT

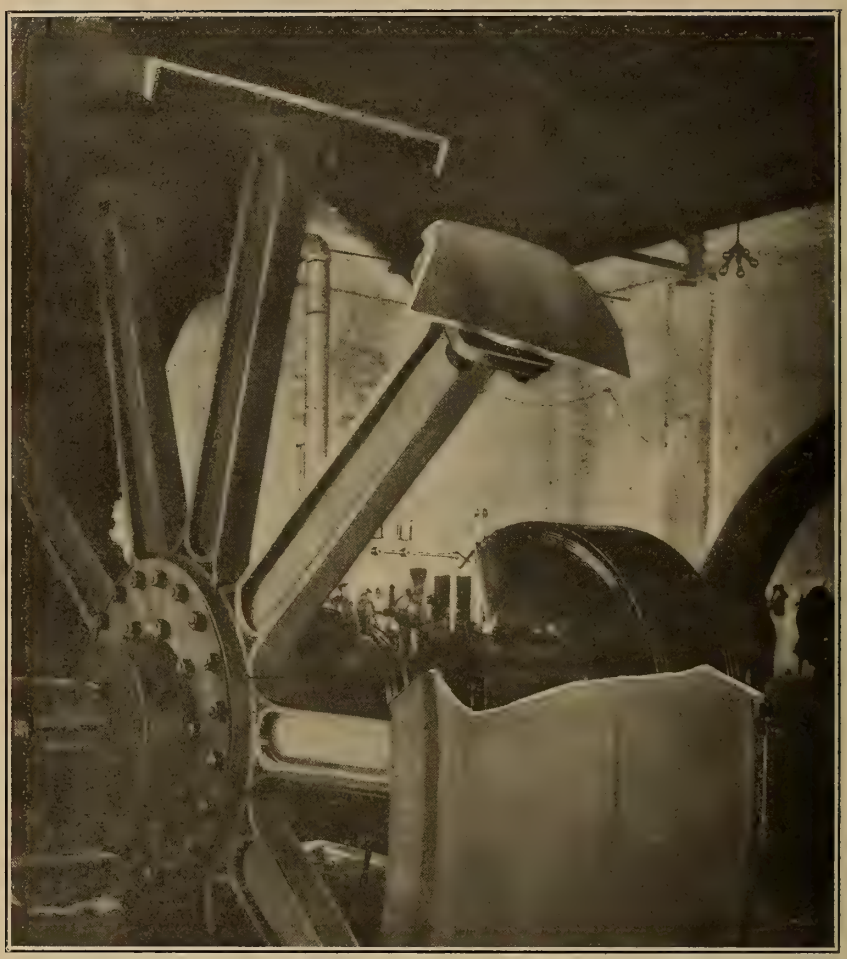
tion with the operation of safety stops when installed in plants operating condensing engines, is the action of the vacuum. If the entire load is thrown off of an engine the mere closing of the main stop valve, or any valve in the steam pipe is not sufficient to stop the engine promptly, as the atmospheric pressure, due to the continuance of the vacuum, still keeps the engine in motion. For this reason various devices have been made for breaking the vacuum, connecting the exhaust of the engine to the atmosphere, and effectually removing this source of danger.

An example of such a vacuum breaker is given in the apparatus forming a portion of the Monarch system. This device has a cylindrical valve in direct connection with the condenser, and kept closed by an armature lever. The magnets are placed in the same electric circuit as the engine stop so that whenever the latter is operated, whether by the speed-limit device or by a push button, the valve is released and is lifted by a spring, admitting air to the con-



THE LOCKE AUXILIARY ELECTRIC VALVE

THE LOCKE VACUUM BREAKER

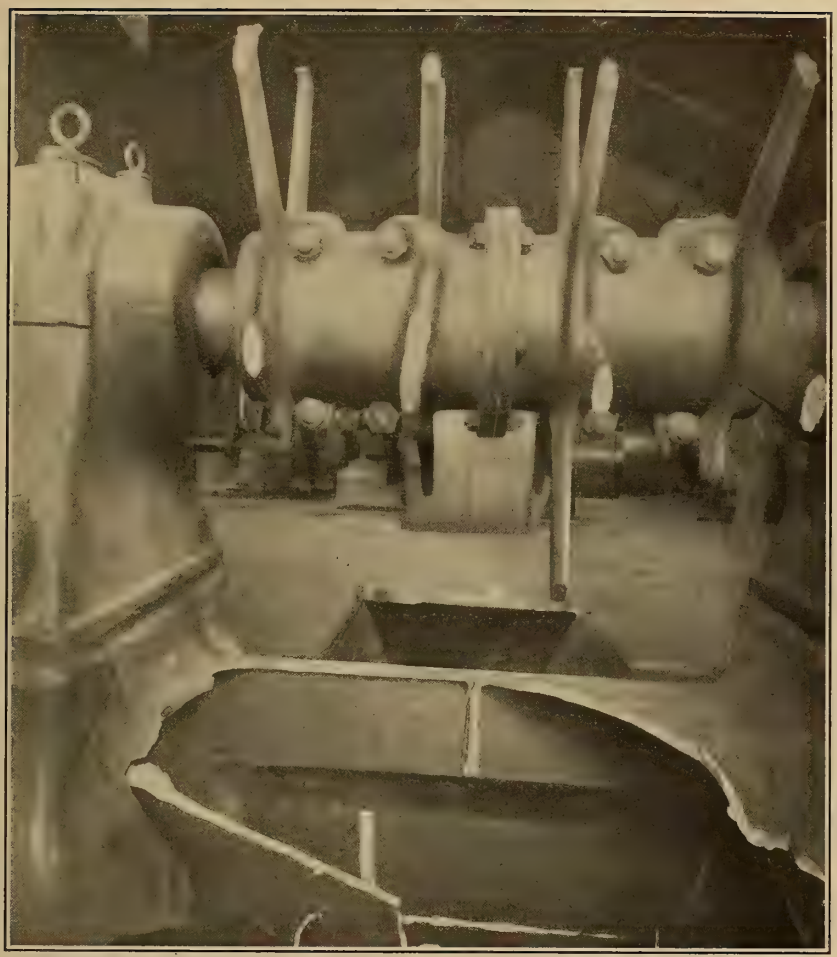


BROKEN FLY-WHEEL, STREET RAILWAY POWER PLANT, LOS ANGELES, CALIFORNIA

denser, and thus the impelling force of the engine is removed simultaneously on both sides of the piston.

Another vacuum breaker is made by the Eynon-Evans Company. This valve is operated by the difference in steam pressure on the two sides of a piston in a cylinder, one side being connected to the steam main and the other to the steam chest. When the stop valve is closed the pressure in the steam chest is very much reduced, and the greater pressure of the steam in the main acts to force the piston down, opening the communication between the exhaust pipe and the air, thus breaking the vacuum in the condenser whenever the engine is stopped.

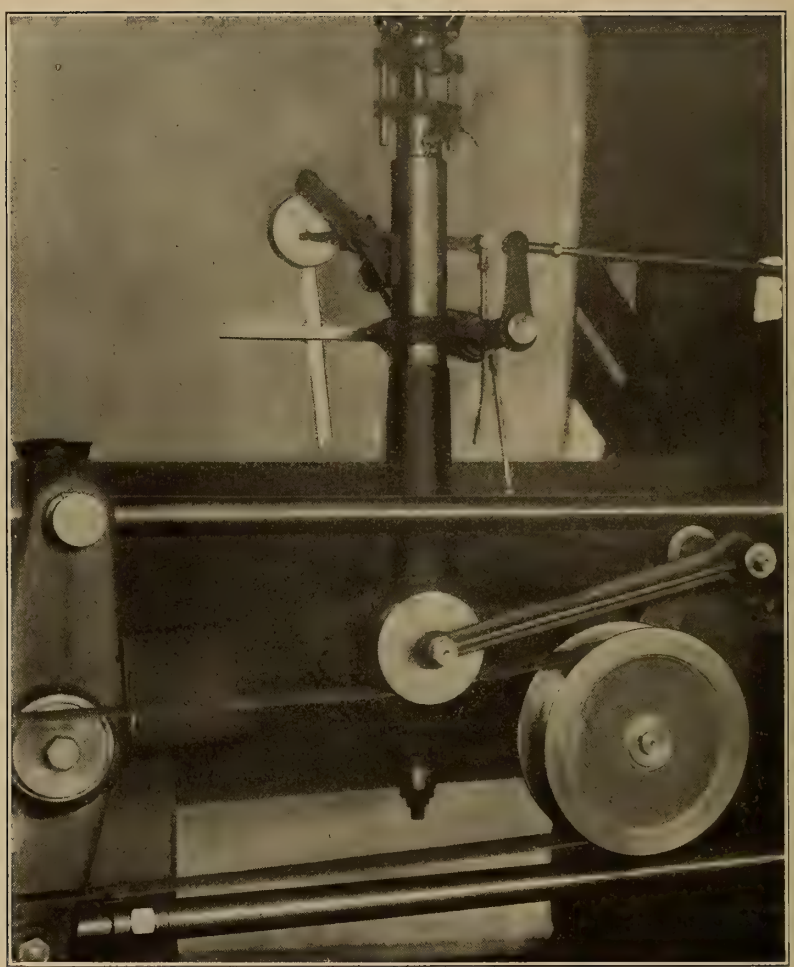
The engine stop made by Hewes & Phillips, of Newark, N. J., is arranged to trip its weighted lever either by mechanical or electrical means and is especially adapted to engines of the Corliss type. The falling weight acts through a lever attached to the rock shaft and controls the cut-off mechanism, bringing the ordinary safety toes on the valve stem toes into action, stopping the further action of the valves. Such a device can be operated electrically from any part of the plant. It is provided with a gravity-actuated



DAMAGE BY BURSTING FLY-WHEEL AT THE POWER PLANT OF THE LOS ANGELES STREET RAILWAY

switch, as well as two cam-plates, the second of which is connected to a lever carrying a loose pulley which rides on the slack side of the governor belt, so that breakage or excessive slackness in this belt causes the engine to stop. In compound engines the device acts on all the valves of both cylinders.

Engine stops, like many other mechanical devices, have "spells" when they fail to work, some little detail of the mechanism giving out. In cases such as the wedged governor, to which reference has already been made, no matter how many safety stops might have been arranged to act through the governor, none would have been of avail. The great difficulty with every piece of mechanism of this sort, whether in the engine room or in connection with some other service, lies in the fact that its operation is what may be termed potential. That is, it does not act regularly and continuously, like any productive piece of machinery, but only in case of an emergency, and hence there are long periods during which it does not act at all; while, when the emergency comes it may not have been in perfect condition for some time, it may thus fail at the critical moment.



HEWES & PHILLIPS SAFETY STOP, SHOWING THE RIDING PULLEY ON GOVERNOR BELT

Nevertheless, the representations of the manufacturers of such appliances are all right, and safety appliances of this kind should be in every engine room, just as every boiler must have its safety valve. It is the rule for them to work, and not the exception, and by keeping them in working order the peace of mind of the employer will be assured and the demands of the employee be met.

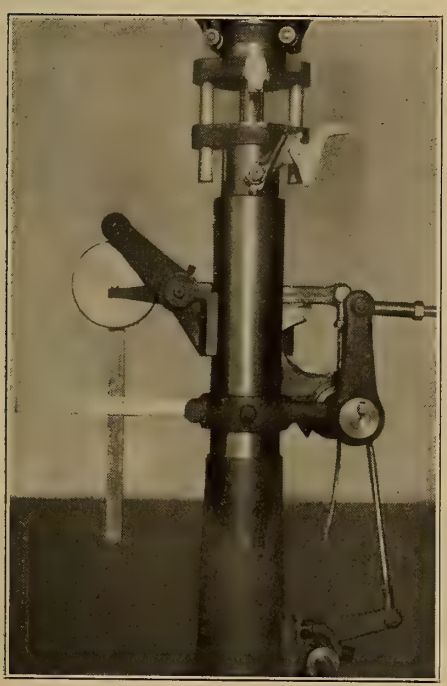
In addition to the provision of safety appliances, however, we have fly-wheel insurance, and its accompanying systematic inspection, including supervision by experts who have made a specialty of the particular question of the prevention of disasters from excessive speed. Inspection may not prevent accidents, but it certainly does discover many things which an operative engineer, with his many routine duties, is not likely to notice. The illustrations of the results of disastrous fly-wheel explosions given in these pages are from the collection of the Fidelity and Casuality Company, New York, and show very clearly the nature and extent of the damage which may be produced by such events.

Thus, in the case of the wreck at the plant of the Mansfield Railway, Light and Power Company, a well-

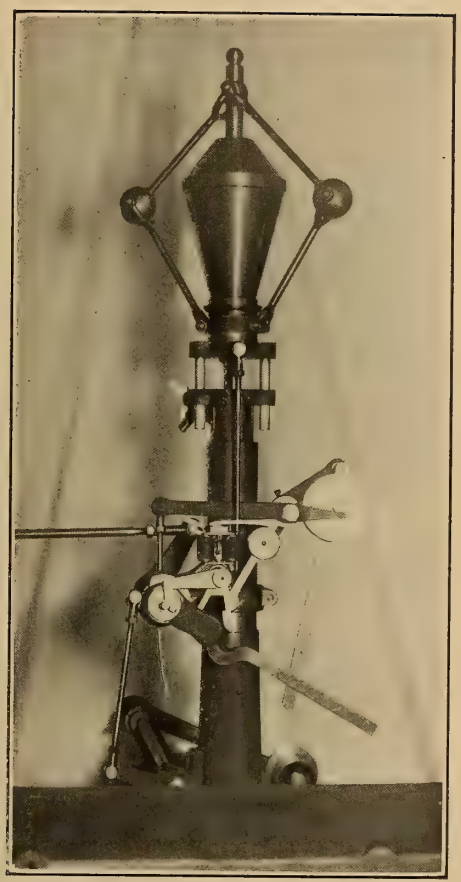
built wheel, free from defects and attached to an engine fitted with a safety stop, burst, causing damage estimated at $9,000, because the main belt broke, throwing the entire load off the engine, while a portion of the belt fell upon the governor and safety stop, breaking both down at the same time.

Another case, reported from Worcester, Mass., in June, 1906, involved the breaking of the main belt of a grain elevator, followed immediately by the snapping of the governor belt, the engine attaining a velocity which caused the fly-wheel to burst, hurling pieces of the rim through a fifteen-inch stone wall partition, fortunately without causing loss of life.

In the case of the plant of the Chicago Coated Board Company, there was a grooved rope wheel, 8½ feet in diameter and 18 inches face, with 10 grooves for a rope transmission. The transmission rope, 1¼-inch diameter and 800 feet long, broke first, it is believed, winding around



REVERSE SIDE OF HEWES & PHILLIPS SAFETY STOP

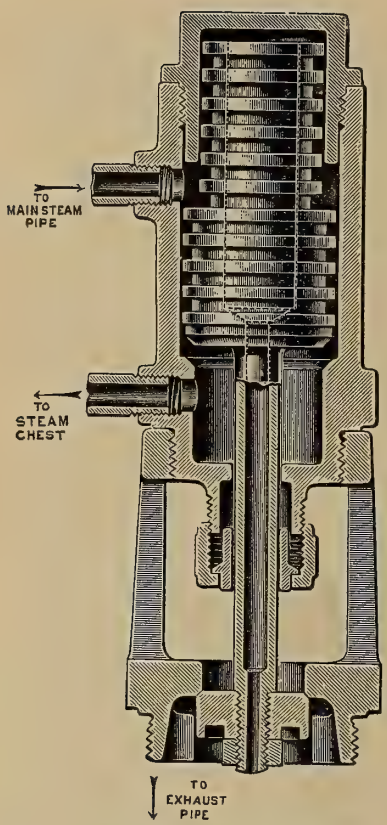


HEWES & PHILLIPS SAFETY STOP FOR CORLISS ENGINES

the tension carriage and breaking the latter, fragments smashing the engine governor, thus freeing the engine of its load and control both at the same time, the fly-wheel bursting by the centrifugal force of the racing engine.

Another example of fly-wheel explosion shown in the illustrations is that at the plant of the Muskogee Gas and Electric Company. Here the wheel which was well built, and apparently free from defects, burst without warning, practically wrecking the engine, damaging a large dynamo and smashing a switchboard.

The illustrations of the damage wrought at the plant of the Bradley Electric Light, Heat and Power



THE EYNON-EVANS VACUUM BREAKER

Company are interesting as indicating the wreck caused, not only in the engine room, but by the pieces of the fly-wheel which penetrated to the floor above. This explosion was caused by the breaking of the main belt, although the engine was equipped with a safety stop.

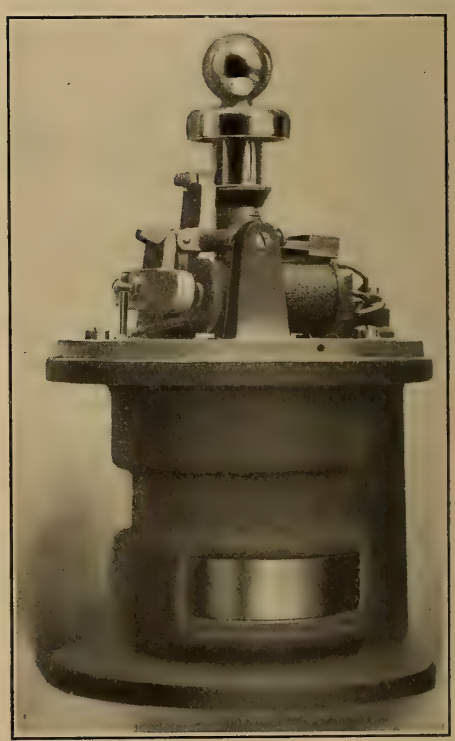
More care is given to the safety of employees on the Continent than in the United States, both as regards explosions and with respect to other accidents. Examples of some of the methods in an automatic steam valve, as used on an engine in Holland, and also in a system of stops arranged to be operated from all parts of a building. An arrangement of shields of wire netting is in use in a German engine room, and has proved very effective in preventing any one from falling into the wheel pit.

Accidents of this sort are more apt to occur than might be imagined, as a recent instance within the writer's knowledge in Brooklyn may testify.

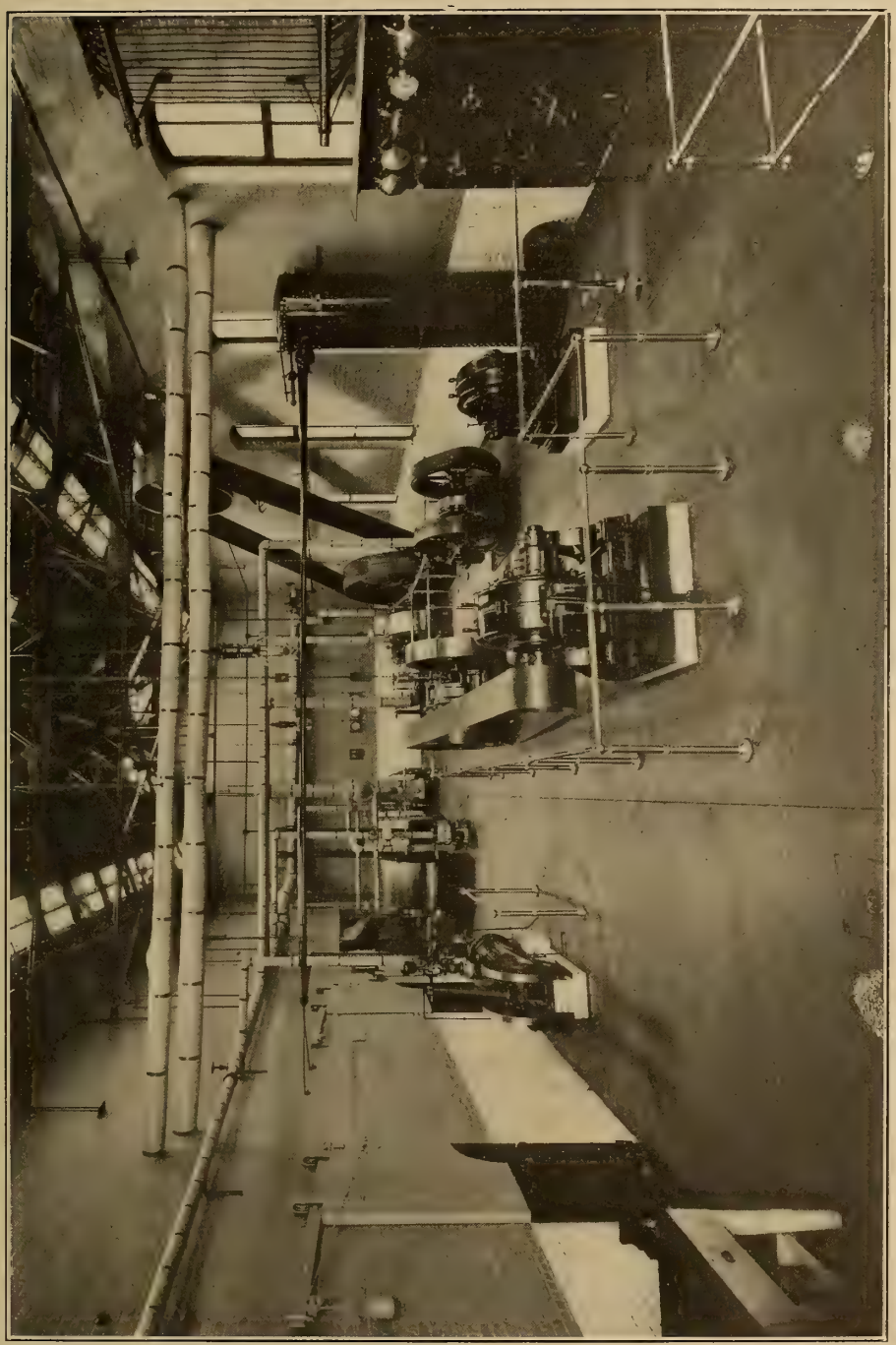
An example of protection in a well-equipped American engine room is shown in the illustration of the engine room of the Paterson Parchment Paper Company, as arranged by the writer, the moving parts of the machinery being surrounded with a fence made of piping, with one or two horizontal rails.

There is no method for the absolute protection against accidents in any engine room or power station; we can, however, supply all possible accessories having for their object the reduction of the number of accidents to a minimum, while at the same time lessening the serious nature of such accidents as do occur.

Apart from the fact that insurance provides for the actual damage



MONARCH VACUUM BREAKER WITH COVER REMOVED TO SHOW CONSTRUCTION



PROTECTIVE GUARDS IN THE ENGINE ROOM OF THE PATERSON PARCHMENT PAPER COMPANY

EFFECTS IN ENGINE ROOM BY FLY-WHEEL EXPLOSION AT THE BRADLEY ELECTRIC LIGHT, HEAT AND POWER PLANT

caused by a fly-wheel explosion, the inspection which accompanies the insurance may act to prevent disaster by giving warning of increasing weakness, and thus furnish protection against both the direct and indirect damage which an explosion may cause. Because a fly-wheel is apparently safe and strong when first installed, it does not necessarily follow that its safety remains constant. The successive stresses upon such a material as cast iron sometimes develop cracks and defects which can be detected by skillful inspection, and give warning in time to enable the explosion to be prevented. Safety appliances, from the very fact that their operation is infrequent, demand periodical inspection in order that they may be maintained in perfect order, and defects that an ordinary engineer might readily overlook are promptly noticed by the practiced eye of the trained inspector.

DAMAGE IN FLOOR ABOVE ENGINE ROOM, BRADLEY ELECTRIC PLANT

The principal defect in safety-stop appliances is that there is a possibility of the stop mechanism being injured and thrown out of action by the very disaster which causes the runaway. A breaking belt or rope transmission may damage the safety stop at the very moment that it causes the load to be thrown off the engine, and in like manner the valve which the mechanism should close may be jammed or blocked from the same cause.

Such instances are noted in the preceding pages, and having such a possibility in mind, the greatest care should be given to the installation of such appliances, so that they may be protected as far as possible from injury in cases of slipping or breaking belts, etc. It has been suggested that two independent speed-limits might well be installed in important cases, the probabilities of both being damaged at the same time being very remote, especially if the two devices were placed at widely separated points on the engine. In every case, however, critical periodical inspection is important, whether made by an independent insurance company or by the engineer of the plant himself.

We are indebted to the Fidelity and Casualty Company of New York for the photographs from which the engravings of the wrecks caused by fly-wheel explosions have been made, and to Mr. William H. Boehm, M. Am. Soc. M. E., the superintendent of the fly-wheel department of that company. Acknowledgements should also be made to the manufacturers of safety stop appliances for data and illustrations.

WORKING AGREEMENTS BETWEEN MANUFACTURERS

By J. F. Gairns

THE day of the small manufacturer as a prominent feature of industry seems to have pased away with the nineteenth century, and the present century is characterized very largely by the combination of previously independent firms into large "combines," or into sets of businesses working together for the purpose of assisting and cheapening production, to facilitate large increases in output, and for mutual protection.

As regards "combines" and "trusts" there is little to be said that is really pertinent to our subject, for such combination firms are intended to work as a single concern, with a single controlling body and offices overruling individual controlling bodies, although the sectional firms comprised by the "combine" may work to a great extent independently. The agreements between the sections are therefore in the nature of working arrangements between the components of a complete concern.

In the present article, however, it is intended to review briefly and somewhat broadly, some of the more important aspects of the subject of working agreements between firms actually distinct and independent, but co-operating for mutual benefit and convenience.

Working agreements between manufacturers may be classified in many ways, such as the following:

1. (a) Working agreements publicly known. (b) Private working agreements.

2. Agreements as to prices of products.

3. Agreements whereby one firm producing or supplying say, raw or partially prepared material, works in conjunction with a firm requiring such material.

4. Agreements to enable large output to be maintained, and orders to be obtained that are beyond the capacities of a single firm.

5. Agreements between two or more firms for the purposes of effective competition with trade rivals. (Such agreements may be of a straightforward character and intended for mutual protection, or they may be for the purpose of obtaining undue advantage).

6. Agreements to enable firms producing or dealing with separate sections of industry to obtain, conjointly, composite contracts, or to deal as a single order, with business involving work for all of them.

In the following remarks these classifications will be broadly adhered to, though necessarily, the sectional classes overlap to a considerable extent.

There are many firms which, though actually distinct in every way, have agreements with competitors, the existence of such agreements being generally known to interested persons. For example, A, B, and C may be separate and distinct firms producing a particular article, or producing articles of the same character but having special features in each case. If such firms are located in towns geographically separated by long distances and a corresponding article is produced by all of them, business can be facilitated if there is a working arrangement whereby each of them supplies only in a convenient district. This may be for the purpose of preventing competition or to render it unneces-

sary for each firm to maintain a staff of travellers, showrooms, branch offices, etc., and to reduce advertising expense; or it may be for the purpose of reducing cost of carriage and assisting general convenience, one firm executing orders on behalf of another firm from its own stock. This latter method of doing business may even be carried to the extent of marking goods from one firm with the name or trade-mark of another firm.

Correspondingly when the productions of each firm possess particular features, all of them will take orders for each type of goods, the orders being transferred to the actual producer for execution, or goods of all classes being stocked by all of the firms concerned.

When such working agreements are generally known, it is realized by purchasers that the firm taking their orders may execute them through another firm whose name and standing is also known. When of a private character, however, such agreements are not always fair business, for it may happen that a purchaser has foisted upon him as productions of the firm with whom he is doing business, articles actually produced by a firm with whom he does not desire business for more or less good reasons. Sometimes, too, it may occur that by this means comparatively unsatisfactory goods are disposed of under cover of a presumably reputable trading concern.

On the whole, however, such working agreements, whether publicly known, or strictly private, may tend to the advantage of producers and purchasers, and for one instance where unsatisfactory goods are supplied under false pretences, probably a dozen instances can be adduced where all parties concerned are benefited.

Agreements classified under II. are generally entered into for protective purposes, to prevent "price cutting." There are many firms who, if allowed a free hand, would carry "price cutting" to an unfair extent, and as this often entails bad material and bad work to maintain a profit, working agreements as to prices are very commonly entered into by all firms engaged in a particular industry, corresponding prices being agreed upon for goods of each character and quality. In practice, however, these agreements are sometimes evaded by means of "trade discounts."

In many industries, to the initiated, a catalogue or price list is a very unreliable and misleading document, for the listed prices have to be reduced to an enormous extent (55 or 60 per cent. in some cases) before the actual prices are obtained. And even if there is agreement as to such discounts, additional discounts are often allowed, such as the usual $2\frac{1}{2}$ per cent. for cash allowed on deferred payment orders. In fact, orders are often obtained merely on the question of which firm will allow most in the way of such additional discounts. In the face of such methods agreements as to prices provide only a partial solution of the price-cutting difficulty. Such agreements are, however, very general, and seem to work well, although they are often honored more in the spirit than in the letter.

In the production of many articles it is only the large firms who can carry out complete manufacture. This difficulty can often be overcome by a series of agreements between firms concerned with sectional manufacture, each supplying their productions to another firm which carries the manufacture a further stage, or one firm selling the finished article and obtaining the individual parts from the firms working with them. A remarkable instance of this latter method of working is provided by the organ building trade. In many cases firms who are styled "organ builders" are little more than organ erectors and tuners. Keyboards, cases, bellows, wood pipes, metal pipes, mechanism, pedal boards, leathers, pallets, and almost all individual parts can be obtained from small manufacturers each specializing in one or two items.

What the so-called organ builder does is to place the parts together, tune and otherwise prepare the organ for use.

The writer has visited more than one organ "works" (sic) where there is only accommodation for three or four organs in course of erection, a few vises, a carpenter's bench, a small lathe and a few other conveniences, the complete staff probably only numbering about half a dozen men and two or three boys. Even the manufacture of bellows weights and pipe gilding may represent separate industries.

Probably a similar state of affairs can be described in connection with many other branches of industry.

Of another class might be mentioned the relation of the cotton and like trades with the dyeing industry. A firm produces fabric, and supplies the whole of its production by arrangement to a dyeing concern whose works are adjacent, and it is the latter firm which really supplies the market.

By such arrangements business may be greatly facilitated. Each firm concerned confines itself to a particular section of work, and its premises and staff are kept within convenient limits, while the purchaser of the completed article may obtain goods of a quality and at prices which would be impossible were the whole work done by a firm which had to maintain all the sections as parts of its own business.

Large orders, if profitable, are always desirable, but sometimes they are beyond the capacity of any but the largest firms. In many instances too, orders are only really profitable on a large scale. In many cases, also, large orders are coupled with delayed payment, and smaller firms cannot stand such methods individually.

A very convenient way of overcoming these difficulties is for a syndicate of firms to combine for the purpose of obtaining larger orders than they can deal with individually, the work, expense and profit being then divided between them by arrangement. In such cases one person or firm generally represents the syndicate for the obtaining and executing the work.

Agreements classified under V. may be good or they may be bad. One difficulty experienced by small firms is the fact that their expenses are larger in proportion than in the case of bigger firms, and single-handed they cannot compete effectively with their competitors who work on a more extensive scale. Working agreements between some of these smaller firms may reduce the field of competition, and may enable them to successfully cope with the competition of their larger rivals.

On the other hand, it is by no means unusual for two or more firms, who would otherwise be competitors, to agree on certain prices and methods for the purpose of crushing their independent rivals. When this is fair business there is nothing to be said against such practices, except that as a result "the weakest goes to the wall," and it often occurs that it is money and size that come out on top, and not worth and quality. Sometimes, however, such agreements are of a reprehensible character, albeit they may be styled, usually, "smartness" and "up-to-date"-ness, for their object is to crush competitors by working at a loss for a time with a view to ultimate profit, or to use one section of business which is conducted at a loss or without profit as a means for obtaining other business which has to provide profit for both.

In some measure the subject matter of our sixth classification section has already been covered, but a few additional remarks will be in place.

Many big trading concerns, particularly those known as "contractors," are really business committees controlling a number of other firms. The individual components may be absolutely independent, and each may deal with its own business, but the "business committee," to use the convenient designation we have adopted,

acting as one firm, obtains composite orders and contracts, utilizing the component firms for carrying out the work.

For example, an electric tramway construction contract is obtained by a particular firm. With this firm—the business committee in question—are associated by agreement a number of other firms. As a result the work is executed somewhat as follows:

Firm A supplies the track equipment.

Firm B supplies the steam engines and boilers of the generating station.

Firm C supplies the dynamos, the transformers at the sub-stations, and possibly also the motors for the cars.

Firm D supplies the overhead equipment.

Firm E supplies the cars.

Firm F erects the various buildings.

These are generally termed "sub-contracts," and sometimes that is a correct designation, but more often the real state of affairs is that the various firms having a working agreement whereby, conjointly, the contracting firm (the business committee) may carry out its work. In such cases there is no competition by tender for individual tender as in the case of "sub-contracts," and the only competition, if any, is between firms of the "business committee" type.

Other examples of similar kind could also be quoted, both on a larger and on a smaller scale, but it is only fairly large contracts that are contemplated by this classification, smaller instances coming under our third classification.

From the foregoing it will be seen that the subject of "working agreements between manufacturers" is an extensive one, and possessing many ramifications. As a rule, they are associated with business facilities and conveniences of a straightforward and strictly honest character, but they also offer opportunities for underhanded dealing (often misnamed "smartness"). On the whole, however, they are a commendable feature of modern business methods, and as time goes on, will undoubtedly become even more extensive than they are. Competition is good and always will be, but in many cases working agreements are better, and although the stress of business nowadays may cause the small man to be stranded, who will not realize the inevitable changes in business practices which time and progress bring forth, the extension of "working agreements" should be an effective answer to the pressure of capital, trusts, and combines, which is also a feature of the development of present day manufacturing industry.

RECENT PROGRESS IN ELECTRIC INCANDESCENT LAMPS

By Lionel Calisch

MUCH attention has in recent years been paid to increase the efficiency of our present electric incandescent lamps. All known illuminants develop large quantities of heat besides light, with the result that the light produced is inefficient, and thus a large percentage of the energy which could be usefully employed in giving out light is merely wasted.

Light in fact is only a by-product in all known illuminants, for the production of light depends on "incandescence," that is the shining of hot bodies, because they are hot.

Such a hot body radiates a variety of waves, but very few of these are useful as light. The useful light rays only appear when the temperature is fairly high; below that only long heat waves appear. By increasing the temperature the percentage of useful light rays increases.

As long as we only know the way to produce electric light by "incandescence" we can only increase the efficiency by increasing the working temperature of our hot body.

Naturally there must be a certain temperature where the percentage of visible radiations reaches the maximum, and this is supposed to be between 4,000°-5,000° C. But even at this temperature the efficiency only amounts to about 8 per cent., so that there is an absolute limit in lighting by incandescence. Perhaps it might be of interest to draw attention to the statement that the temperature of the sun is about 7,500° C., and that only about 25-30 per cent. of the total amount of energy is turned into light.

The familiar electric incandescent lamp consists of a filament of carbon enclosed in a vacuum. The carbon filament is heated by the electric current and forms our hot body. Now carbon is apparently the most refractory of all substances, its boiling point being about 3,800° C.

Unfortunately we cannot use such a high temperature in the carbon incandescent lamp, for our limit is not the boiling point, but the temperature at which the evaporation becomes so great as to limit the life of our lamps. The temperature at which we work carbon in our lamps is about 1,800° C. and the average efficiency is about 3 to 4 watts per candle.

The efficiency of the incandescent lamp can therefore be increased by using a material which has a lower vapor tension at a higher temperature.

This problem has in recent years been vigorously attacked, and there are now lamps on the market having efficiencies ranging from 1 to 2 watts per candle.

Nernst was the first to devote his attention to the problem and brought out the well known Nernst lamp. The filament consists principally of zirconia, magnesium oxide and a small amount of the oxide of the yttria group. The conduction is electrolytic, as can easily be shown. Take the case of a pure magnesium oxide filament burning in air with a direct current. Oxygen escapes and the pure metal burns again to oxide.

Great hopes were entertained when the Nernst lamp appeared on the market, but these have not been realized, for the lamp had one great disadvantage which has never been overcome, namely, the filament does not conduct and consequently does not light up at ordinary temperatures. It must first

be heated, and in order to make the lamp practical a small heating coil is provided which heats the filament until it lights up and is then automatically cut out of the circuit. A Nernst lamp takes on an average of about 30 seconds to light, but this fact of course takes away the great advantage of electric lighting, namely, the instantaneous production of light when switching on the current.

The efficiency of the Nernst lamp is fairly high, about 1.7 watts per candle, but its life is not so long, about 600 hours. The lamp is, of course, a distinct advance over the carbon filament lamp, but for reasons stated above it has not been a success.

Welsbach, who introduced the incandescent gas mantle, was next in the field, but instead of turning his attention to electrolytes he searched the rare metals and succeeded in making a lamp having a filament of osmium. This lamp combines a long life (about 1,000 hours) with a high efficiency, about 1.2 watts per candle. The first lamps were only made for low voltages, but recently 32-candle-power lamps have been placed on the market suitable for 110-volt circuits.

The appearance of the osmium lamp marked an epoch in the electric lighting industry, for it gave rise to a series of further discoveries which promise well for the future.

Seeing that Welsbach had succeeded with osmium, inventors began to turn their attention to other rare metals, of which the following have been used with success: tantalum, tungsten, zirconium, iridium.

The tantalum lamp has so far been the most successful of all metallic filament lamps and thousands are now in use in London alone.

Dr. Werner von Bolton, chemist to the Siemens & Halske Company in Berlin, devised a way of drawing tantalum into thin wire and succeeded in making a practicable lamp having an efficiency of about 1.7 watts per candle and a life of 1,000 hours.

Twenty-five candle-power lamps are made for 110-volt supply circuits. Such a lamp has a filament 650 millimeters long and a diameter of .05 mm. Owing to the lengthy filament, the lamp gives an excellent light distribution which, combined with the whiteness of its light, makes it very pleasant in use.

A curious phenomenon in connection with the tantalum lamp is that it cannot be used on alternating-current supply circuits. The reason for this is that tantalum being a metal, an oscillating motion is set up which crystallizes the filament. At a frequency of 25 the life of a tantalum lamp is about the same as with direct current, but at higher frequencies the life is enormously shortened. The average result of some recent tests on these lamps showed a useful life of about 600 hours and an average efficiency of about 2.2 watts per candle.

Dr. Kusel, of Vienna, was the first to introduce tungsten, but it is doubtful if he ever made a pure tungsten lamp. A whole series of lamps have been brought out named the Osmin, Osram, and Tungsten, manufactured by different companies, in which the filament consists of an alloy of tungsten and osmium. Very few reliable data are obtainable with reference to these lamps, as they have hardly passed the experimental stage.

A recent test on a 110-volt 32-candle-power Osram lamp showed an average efficiency of 1.2 watts per candle and a life of about 500 hours.

All present metallic filament lamps must be burned in a horizontal position, owing to the softening of the filament. The tantalum lamp is at present the only one which can be burned in any position.

A remarkable metallic filament lamp has recently appeared which at present seems to eclipse all others. It is known as the Zircon Wolfram lamp, the invention of Dr. Zernig, of Berlin, and is the only metallic lamp which, so far, has been made for 200-220-volt circuits. The filament appears to be an alloy of zirconium and tungsten, but it may be that the

filament is not an alloy but a zirconide. The introduction of tungsten into this particular lamp has enabled an extraordinary advance to be made. A year ago this lamp could only be made for 37 volts; to-day the pressure has been raised to 220, while the candle-power is not very high, about 40-50. The efficiency is very high, about 1.2 watts per candle, and its life is about 1,000 hours, while the lamp burns equally well with either alternating or direct current.

Summing up the present state of metallic filament lamps, it can safely be stated that, in spite of the great improvements that have taken place and the advance that has been made in incandescent lamps, they have hardly passed the experimental stage.

One of the difficulties is to make a small candle-power lamp for high-voltage circuits having a filament which will stand shocks and vibration. The development of the new lamps is chiefly a chemical proposition of the most difficult nature, and great credit is due to the experimentalists who have given us the present new lamps. Mr. Swinburne, in a very able paper read before the Institution of Electrical Engineers on Jan. 10, 1907 (see *Electrician*, Jan. 18, 1907), goes very fully into the physical and chemical properties of different materials which are available for the manufacture of lamp filaments. There is no doubt that within a very short time we shall have at our command metallic filament lamps which, from a practical point of view, will equal the present carbon lamp and have an efficiency of 1 watt per candle.

This will be a great achievement, but it will not be the lamp of the future. For, as shown in the beginning of this article, we are absolutely limited as long as we cling to incandescent bodies for light production.

Heat, although capable of making a liquid or solid incandescent, cannot make a gas incandescent, but merely increases its pressure. We can, however, set the gas molecules in vibration by chemical reaction or electric stress, such as is done when an electric current is passed through a vacuum tube. A luminescent gas is far more efficient as a producer of light the lower the temperature, because a certain definite vibration is directly produced by the electrical energy which sets up the oscillation, and the heat produced is only a by-product, which is exactly the reverse of what takes place in "incandescence."

Theoretically, there is no limit to the efficiency of a luminescent gas. Within the last few years good efficiencies have been obtained with the Moore vacuum tube illumination, and this method of light production has a great future before it. The light of the future will be a lamp giving light without heat, and the probabilities are that this will be either a luminescent gas or vapor.

BRITISH TANK LOCOMOTIVES

LONG-DISTANCE TANK ENGINE

By J. R. Thompson

If we may judge how the almost simultaneous appearance upon three or four leading lines of railway of a new class of tank locomotive of relatively gigantic dimensions we should be justified in the assumption that the too long neglected merits of this type are beginning to be recognized to some purpose.

The latest convert to this way of thinking appears to be Mr. Deeley of the Midland Railway, who has just turned out from the company's works at Derby a six-coupled trailing-bogie side-tank engine for passenger service, which is capable of dealing with fast and heavy traffic and of covering, without a stop, distances which only a very few years ago would have been out of the question.

This fine engine, which in the current system of notation would be $\frac{0-6-4}{T}$ styled, compares in point of size and weight with Mr. Churchward's "County" class of tank engines on the Great Western, or Mr. Whale's new "Precursor" tanks on the London and North Western, but excels both in its capacity for water and coal storage; the side tanks being prolonged forward to the smoke-box front in addition to a rather unusually large kind, or bunker tank. Altogether 2,250 gallons of water can be carried, an amount equal to the storage capacity of many six-wheeled tenders.

The radius of action, to use a sea-going phrase, is not, however, limited by even this amount of water. A reversible scoop is fitted, for use in either direction of running when on a part of the line fitted with water-troughs.

In passing, we cannot help remarking upon the length of time that elapsed before other railway companies took up the late Mr. Ramsbottom's invention for supplying water while travelling at speed, which alone has rendered possible the phenomenal non-stop runs now practiced.

With the provision of 3½ tons of coal in the bunker, this engine should be able to give a good account of itself with any run of ordinary express distance.

The boiler, with 1331 square feet of heating surface and 21.1 square feet of grate area, is of the standard Midland type and works at 175 pounds pressure. The cylinders are 18½ inches by 26 inches and the coupled wheels are 5 feet 7 inches diameter, with 3 feet 1-inch bogie wheels: the total weight in working order being 72½ tons, of which nearly 53 tons is available for adhesion.

There is one feature in this engine which, so far as we know, is absolutely novel, in that the cylinder centres are not coincident with those of the crank-throw journals. We have known this to occur through the inadventure of a designer, and to be regarded as a very serious error: but that the connecting-rods should be intentionally splayed inwards half-an-inch each cannot but be considered as a bold departure from the recognized laws of fitness.

The total wheel-base is 29 feet, the coupled wheel-base being 16 feet 6 inches, but as the leading axle is allowed 1¼ inches side-play, and the trailing bogie a lateral spring-con-

TANK LOCOMOTIVE FOR LONG-DISTANCE SERVICE ON THE MIDLAND RAILWAY OF ENGLAND.

trolled movement of $5\frac{1}{2}$ inches the engine is of unusual flexibility and can take without difficulty curves of four chains' radius. To permit of this $1\frac{1}{4}$ inches movement upon the leading axle, both the connecting-rod small ends and the forward halves of the coupling-rods are fitted with brasses which are spherical externally so that no binding can occur. We have no doubt that this new engine will, as a class, amply fulfill its purpose as a reliable and effective type of long-distance passenger tank engine, and we congratulate Mr. Deeley upon this latest addition to the Midland locomotive stock.

In the near future we hope to see Mr. Whale of the London and North Western "go one better" than his splendid "Precursor" type of tank engine, and produce his "experiment," $\frac{4-6-0}{T}$ type, which we believe would be the equal of anything running upon wheels at present.

Mr. Ivatt, of the Great Northern, has also just brought out a very fine $\frac{0-6-2}{T}$ six-coupled radial tank, or engine, having 18 inches by 26 inches cylinders, 5 feet 8 inches coupled wheels, 1250 feet heating surface and $20\frac{3}{4}$ feet grate area; carrying 1600 gallons of water and 4 tons of coal; and weighing 64 tons in working order, of which 51 tons is available for adhesion. This is, however, a condensing engine for metropolitan duty and hardly comes under our heading of long-distance tank engines.

It is, however, to the Great Western Railway that we must turn for real activity in the scheming and production of fast and powerful tank engines for passenger service, of which there are several classes at work all in turn designed by the enterprising and indefatigable Mr. Churchward, of which we hope to give some particulars in a following issue.

THE CENTRAL STATION AND THE ISOLATED PLANT

CONSIDERATIONS GOVERNING THE SELECTION OF EACH CLASS OF SERVICE FOR INDUSTRIAL PURPOSES

By H. S. Knowlton

IN the establishment of many kinds of modern business the question of cheap power is one of fundamental importance, and in not a few cases the industrial manager finds it a most difficult problem to decide between installing an isolated plant and contracting for central station service. The relations between privately generated and outside purchased power, including heating and lighting service, have often been discussed from the standpoints of the central station man and the isolated plant engineer, but much less has been emphasized from the point of view of the consumer. In a general way, the lowest estimated cost of power per kilowatt-hour for the service anticipated has been the deciding factor in competitive analyses of the policies desirable with respect to installing a private plant or buying service from the central station or transmission company. This is the proper basis for a decision, but it is well to remember that the minimum cost per unit of power generated or delivered is dependent upon more factors and conditions than are usually appreciated.

The central station and the isolated plant are competitive in certain fields and probably always will be; but on the other hand, the conditions are often so definite in favor of one or the other that competition has no excuse for existence. What is needed most in the isolated plant problem is a sound appreciation of limitations. The problem will be solved when the advantages and disadvantages of both services are weighed impartially with the determination to work out the most economical result, allowing for all the charges, conveniences contingencies and emergencies which can be brought to bear upon the case in hand. Expert advice will often be needed in doing this, but whether the consulting engineer be retained or not, the main points at issue ought to be thoroughly understood by the prospective power user.

Every condition bearing upon the selection of a power supply should be given some sort of financial value. Obviously the first task to attempt is to determine as closely as possible the immediate power needs, considering average, maximum and minimum loads at different hours of the day and, if possible, at different seasons of the year. The value of the load curve in analyzing the inside economy of an industry is very much greater than many managers appreciate. The mimimum cost of power production depends on the operating side so closely upon the approximation toward full load conditions which can be secured in unit machines, that only by estimating the load factors of the plant at different hours and seasons can any reasonable basis of running cost calculation be attained. In an established industry load curves are comparatively easy to secure, but if the installation is entirely new, the expected loads at different times must be estimated on the strength of what other plants in the same business are doing, supplemented with whatever special knowledge can be had of the possible causes of variation in local operating conditions. In addition to the immediate power needs, there must be estimates of maximum and minimum power requirements for as far ahead in the future as the conservative judgment of the manage-

ment warrants. In figuring problems of this kind, inexperienced men are usually satisfied with making a single set of assumptions, and well-rounded power schemes cannot be built on such narrow foundations. It is not difficult to set the maximum and minimum limits of probable power demand in any well managed industry, for at least a year or two in advance, and the compromise between these is likely to be much closer to the truth than an unlimited estimate formed on one set of conditions.

Given the probable load curve of the plant, the capacity guarantees of responsible manufacturers and first cost propositions for equipment, it is a short piece of work to determine the necessary investment to handle the business. Operating expenses, including maintenance, supplies, labor, fuel, etc., can then be figured, and the unit result with reference to the load curve assumed is the net cost of power per kilowatt-hour. Too often the prospective plant owner stops short at this point, failing to add the fixed charges of interest, depreciation, insurance, taxes and value of the space occupied by the plant per kilowatt-hour to the production cost. Thus, assuming a 300-KW. isolated plant costing installed $300,000, the net cost of generating power on a 30 per cent. load factor 300 days in the year may by good management be brought as low as 2.5 cents; but adding fixed charges, consisting of 5 per cent. interest, 8 per cent. depreciation and 2 per cent. insurance, taxes and space valuation for renting or storage, we find 0.7 cent more to be added, making the actual power cost 3.2 cents per kilowatt-hour. This figure is close to some of the most favourable central station rates, and if the outside current is based on water power generation the decision will scarcely favour the isolated plant unless the question of heating by exhaust steam is prominent.

Owners of isolated plants are frequently inclined to assume that their power costs little or nothing from the fact that the exhaust steam from the generating units is thrown directly into the heating system during the months of cold weather. It is urged that the boiler plant has to be installed anyway; that skilled supervision must be hired for the heating plant, and that the power plant can be tucked away in the basement in a corner which will be of no use otherwise. Certainly the use of exhaust steam in heating will go far toward reducing the cost of fuel and water per kilowatt-hour to a very small fraction of a cent during such time as the exhaust steam is actually used in the heating system; but the labour cost, maintenance and fixed charges must remain about the same in any case, and as a matter of fact it is a common sight, even in cold weather, to note an excess of exhaust steam being discharged from the head on the roof of a plant, showing plainly that the heating system is taking only a part at least of the exhaust. These points are mentioned, not to favour the central station, but to show the need of considering the hard facts of the case in trying to find out whether the isolated plant will pay better than the service of its rival.

Central station service has an important advantage in its relatively unlimited capacity. Except in the case of isolated plants located on large factory grounds or their equivalent, expansion beyond the 100 or 200 per cent. limit is likely to be exceedingly difficult, if not impossible. As far as the consumer is concerned, the central station is practically inexhaustible. The consumer can quadruple his motive power in a week, creating but a very small stir in the generating and distributing system of a large central station; there are no worries about the erection of engines, generators and piping; the strike question is practically eliminated, and the speed of the installation is not dependent upon the deliveries of prime mover or dynamo manufacturers. In the case of the securing of a very large contract on a rush order basis,

requiring additional power facilities immediately, the readiness of the central station to step in and make the temporary connections entirely distances the possibilities in the way of permanent or semi-permanent extensions. There is no doubt that the machinery operating problem is much simplified by taking central station power, and the consumer is left to concentrate his energies upon the details of his own business—always a desirable result in these shortening days of increasing mental stress and strain.

The larger the central station, the stronger will usually be its claims on the score of reliability of service. On this feature of the question often rests the selection of the independent plant or the contract with the power company. The smaller the station, the less is the certainty of its giving continuous service, year in and year out, without a break. The larger the isolated plant, the more continuous will be its output, for the same care per employee. In great cities where the central stations are two or more in number, with reserve capacity in storage battery sub-stations to tide over any unusual cut-off of power from the bus-bars of the generating plants; where all the distributing circuits in the business districts are installed in modern conduits, the chances of interruption are remote indeed. In some industries, as in lead smelting, continuous service must be had at any price, for the product is spoiled and valuable machinery damaged by an interruption of even two or three minutes. Hence, if the central station supply depends entirely upon a distant hydro-electric plant and the connecting link of a high potential transmission line or two from 20 to 150 miles long, the chances of the isolated plant for giving continuous service will be practically as good as the central station, if not better in cases where the line is greatly exposed. Power transmission engineers are working hard to reduce the chances of temporary shut-downs, and a careful study of transmission plant and line designs in the past five years will show a greatly improved factor of safety in this respect. The use of steel towers instead of wooden poles in some of the higher voltage and longer distance transmissions is a long step in the direction of reduced line troubles, and the extraordinary care and space allowed in installing very high voltage wiring in stations is also a valuable improvement. There is a tendency at this time, however, to suppress information in some transmission systems as to the actual percentage of time which should be allowed for shut-downs, and the uncertainty as to what may be expected in this direction is a powerful factor in favour of the isolated plant. There is not the least doubt that if power companies would frankly open their break-down records with explanatory causes to the inspection of prospective customers, much greater confidence would be the result in cases where the points are close.

There is no mistaking the fact that the whole tendency of modern industrialism is still strongly in the direction of consolidation and concentration. Economy of production and management, of distribution on a large scale and of commercial sales organization, all are proportional to the centralization of equipment control and administration. The ability of the central station to generate power more cheaply than the isolated plant is unquestioned, given the same type of equipment in each case. The advent of the gas engine and oil engine has done much to cut the cost of power production down to bottom figures, even in isolated plants of two or three hundred kilowatts capacity, but if these revolutionary types of generating apparatus maintain their efficiency as the years pass by, it is only a question of time when the central station itself will enjoy the operating economy of mammoth generating units which will be capable of bettering the performance of any segregated installation for office building,

factory, hotel, or other private service. We may take it for granted that the isolated plant can never, in the long run, hope to beat the central station at its own game of minimum power production cost.

The isolated plant retains its hold upon the private power situation for two principal reasons: The cost of distribution and the cost of reasonable profits on the central station investment. These are the crucial points. No amount of engineering and administrative skill in the power station can entirely offset the cost of distribution and the necessity of reasonable returns on the power company's legitimate capital. The centripetal tendency toward consolidated operating economies is offset in part at least by the centrifugal tendency toward increased cost of distribution per unit sold as the area of supply is extended. To the modern central station man it seems preposterous that scores of small installations, often poorly operated, with wretched load factors, inferior supervision and an oft-times reckless disregard of fixed charges, should be tolerated by keen business men. Duplication of generating capacity seems to him an idle waste of capital. But the incubus of distribution cost sets the limit to the minimum profitable power rate, and far too often there is a lack of exact information as to the cost of distribution to particular customers. The problem of ascertaining it is one of the utmost difficulty, as far as making its influence felt on specific rates is concerned, but it is one of the most fascinating questions in the field of modern electrical engineering.

If the isolated plant should go, who would be the loser? Assuming the same reliability of service, the consumer would not be out of pocket if the central station meets his total power cost figures on the private generating plant basis. The engineer who makes a specialty of isolated plant work would have to confine his practice to local installation, distributing and utilization problems in the plant itself. There is plenty of room for good practice in this field. The selection of the best equipment for the particular service in hand, its best disposition and its proper operation and maintenance are all matters requiring expert supervision. The machinery contractor who builds dynamos, engines, boilers, feed pumps, etc., will scarcely lose in the long run, although he may be obliged to alter the types of product which he manufactures. For every 100 kilowatts in generating capacity removed from the isolated plant we must add from 120 to 150 kilowatts at the central station itself—in the long run. The item of skilled supervision in the isolated plant will be reduced in cost, depending on the size and scope of the installation, but it is doubtful if a single man in any plant of less than 500 kilowatts rating would "lose his job" by the cutting out of the power generation system in the isolated plant itself, unless the central station supply included a large heating proposition on the underground steam delivery system. We cannot lose sight of the influence of the heating problem on the entire isolated plant question. The tenant of the office building, the guest in the hotel, the workman in the shop department, the municipal officer in the public building—these typical consumers care only for results at the lowest total cost, and if we follow the interested parties all down the line from the engineer to the supply dealer we shall find that few serious ultimate losses would result from the extinction of the isolated plant, supposing that ever occurs. In these paragraphs the interests of the industrial consumer are the basis of discussion, and we may safely take for granted the assertion that if the same service can be furnished by the central station at equal or less cost, then the isolated plant has no excuse for being. No one dreams of the extinction of the central station; it stands upon the solid foundations of maximum potential generating economy and minimum in-

convenience to the customer, and even in the face of complex distribution charges and rate making processes which a none too friendly public finds difficult to understand, there will always be a large clientele for the commercial company to supply.

Having attempted to describe the circle of important conditions sursounding the isolated plant problem—and perhaps the reader already feels that he has been set down close to his starting point—let us sum up the needs of the case with the future in mind. Under ideal conditions there would be little reason to install isolated plants. Under present conditions there are arguments for each side of the case. The ultimate standard is that of dollars and cents, and wherever the decision is close, the investigation must be made with expert thoroughness in order that the industrial manager may act wisely. The central station man must know his distributing as well as his generating costs, with closer accuracy, if his rates are to meet the competition of a larger number of isolated plants. He must be able to explain in convincing language why the charges are justly from two to four times as high for lighting current drawn from the same bus-bars and sometimes from the same distributing circuits as the power current. The isolated plant manager must learn to figure the pitiless fixed charges in getting at his power cost, and to make the kind of allowances outlined above in calculating the labor item in the expense of power production. The consulting engineer can help both the central station man and the isolated plant owner in running this kind of data to earth. There is at present a notable absence of reliable isolated plant statistics, and it is hard to estimate what can be done in the way of reducing power costs on each side of the line between the private plant and the central station.

Finally, the industrial world at large will be best off when all needless duplication is avoided. There is no escaping the fact that that state of things favors the central station in most cases, but the practical business of electrical and heat supply, as well as refrigeration supply, will have to be greatly improved before the isolated plant will be needed no more. Perhaps the conditions will never become so fixed, and yet there are cities in this country to-day depending on hydro-electric central station service which contain scarcely a single private generating plant. The industrial value of local water power is too great to be rivaled by steam. As far as one can foresee conditions of industrial power supply, there will be room for many isolated plants for a long time to come, but the slow tendency of the times is in the opposite direction. Conditions are still contradictory; and it is hard to reach definite conclusions as to the future of the isolated plant. The object of these paragraphs will be attained if they succeed in suggesting any of the problems of the isolated plant policy in a way helpful to the consumer and in stimulating all concerned to a closer analysis of their costs and operating methods.

THE BELMONT TUNNEL IN NEW YORK

By H. H. Kress

REMARKABLE progress has been made on the Belmont tunnel now being constructed under the East River, New York. This tunnel and subway is over 3 miles in length, extending from Park avenue and Forty-second street, Manhattan, to Jackson avenue and Fourth street, Long Island City, and will afford easy and quick transit between the boroughs of Queens and Manhattan, connecting with the Interborough system of subways near the Grand Central Station.

The first shaft was started July, 1905, and the work has been rushed with tremendous vigor, night and day, ever since, and it is expected that both tubes will be completed and in full operation the latter part of this year.

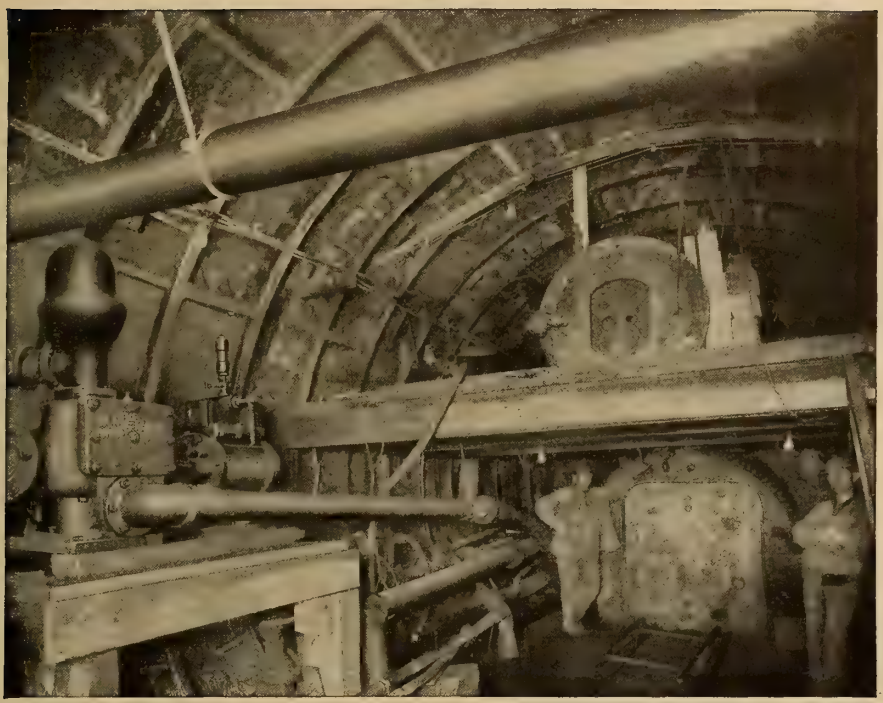
This tunnel consists of two tubes running parallel, and each arranged for single tracks. Parts of the tubes are horseshoe shaped, while under the river bed they are circular and built of sectional cast iron rings, all substantially made and safe to a degree far in excess of what is required to carry the heavy electric trains, similar to those used by the Interborough road, that will be needed to convey the enormous and steadily increasing traffic which is anticipated.

The Degnon Engineering & Construction Company are the builders of this tunnel, and have a complete equipment for handling the work and are using the most modern methods. They are taking every precaution to insure the health of the men and safeguard lives and property.

There are five shafts or entrances to this tunnel:—two on the Manhattan side, two on the Long Island side, and a shaft in the center of the East River on Man-o'-War Reef. The latter is on a coffer dam built in the river by the contractors with the government's permission.

Parts of the tubes were driven by the single bench method under atmospheric pressure; but under the river bed the shield method was substituted and the subaqueous tubes were continued by the shields, cutting their way forward and pushed by the powerful hydraulic jacks operated by compressed air. The shields are 15½ feet in diameter, the exact size of the cast iron shells which are set in place and bolted together.

Compartments, or "air locks," as they are termed, are formed between the shields and the finished tunnel by steel bulkheads, and the pneumatic pressure, which is maintained equal to the hydrostatic pressure at the center line of the tubes, holds up the river bed and prevents the water from drowning out the workings. There is, however, an accumulation of water coming into the workings from the bottom of the tubes where the "sandhogs," so called, are at work, and where the hydrostatic pressure is greater than the pneumatic pressure. The water is collected in temporary sumps constructed in the air locks, and from there is forced out by the air pressure through the pipes to the various pumping stations that are situated along the line of construction. This method readily takes care of the water from the air locks, but there is a constant seeping through joints where the calking has not been completed, as well as an accumulation of drainage water coming into the tubes which is collected in



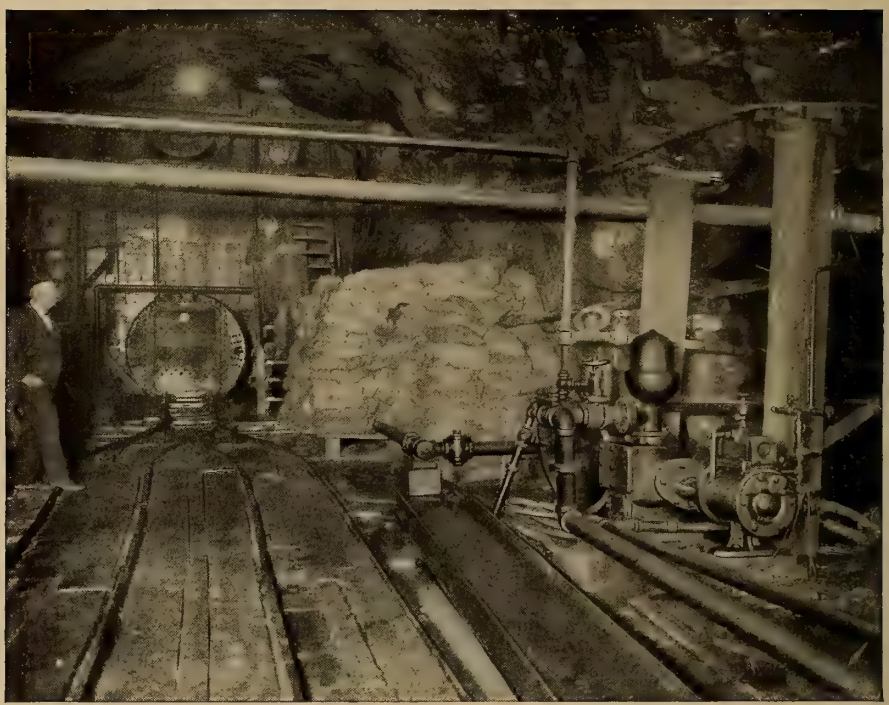
VIEW OF BELMONT TUNNEL TUBE BEFORE LINING WITH CONCRETE, SHOWING OUTSIDE OF AIR LOCK AND PUMPING STATION

the various sumps situated where the grade is lowest and where the pumping stations are placed, and pumping the water to the surface or directly into the river or sewers connecting with the river.

In several places the segments or wall plates have been removed and the rock and other material forming part of the 8 feet of partition between the two tubes were cut through to provide for the sump chambers and allowing room for the pumping stations. Where the pumps are situated alongside the tunnel walls and in the workings, no extra room was required for their installation, as they are all of the Cameron design, having the well-known Cameron characteristic of compactness and occupying but little room.

The engineers in charge of this work have readily recognized the advantages of this type of pump for this and similar underground construction work on account of their having no outside valve gear and entire absence of moving arms or levers to become broken or get out of alignment. These pumps are massive in construction, to prevent injury from blasting, falling rock, and debris. They can be relied upon in case of sudden flooding into the excavation and caisson linings, and will work as well under water as above. In emergencies or accidents, the normal capacity of these pumps can be doubled, as occasionally occurs when they are run at a piston speed of over 200 feet per minute.

A unique and simple device is attached to the pumps to keep the exhaust compressed air from freezing in the air cylinders. A small pipe is connected from the discharge water pipe to the exhaust openings on the air cylinder over which the spray from a $\frac{3}{8}$-inch nozzle flows constantly while the pump is running, thus



A FORMATION OF SOLID ROCK IN THE LINE OF THE TUNNEL. THE CAMERON PUMP IS HANDLING THE DRAINAGE WATER

equalizing the temperature about the exhaust chamber and preventing freezing. This simple device also acts as a muffler on the exhaust, which would otherwise be deafening to the workers in these closed tubes.

There are many trying conditions constantly arising with the drainage problems, and every care is being taken to prevent the drowning out of these workings. Compressed air is the motive power for the pumps, drills, hoisting and other machinery, and is supplied by the four large power plants situated at the top of the shafts.

Current Topics

THAT the passenger service of suburban and cross-country trolley lines has done much to raise the standard of living in rural communities is widely appreciated by students of transportation. Any agency which binds the country districts and the cities more closely together is a welcome addition to the resources of civilization, and there is no doubt that, on the whole, the electric road has proved to be a great boon to both city and country residents in cases where it has made it possible to journey back and forth without too great a sacrifice of time. The full usefulness of the cross-country trolley will not be realized, however, until more liberal provision for the carrying of light freight is made in localities where the present traffic is passenger business exclusively. Considerable difference of opinion as to the desirability of light freight traffic now exists among the managers of electric railways, and it is an open question to what extent cars loaded exclusively with merchandise should be permitted to operate in the congested districts of large cities during the daylight hours. The handling of light freight between the mercantile quarter of a city and the residential, suburban, and outlying rural sections means terminal facilities in the city itself when the volume of business becomes large, and many broad problems of freight classification, rate schedules, car routing, and arrangement of service to avoid conflict with passenger traffic must be solved before any considerable success can be attained.

As far as local trolley expresses have been established, their value and efficiency from the standpoint of the public has usually been so great that it is only a question of time when the vast majority of electric roads will, from the nature of things, provide some sort of facilities for the handling of light freight. Where trolley express service has been tried, it has usually begun with the carrying of small parcels for the patrons of the road, chiefly as a matter of accommodation. The service grew out of a necessity, and its expansion into a service carrying parcels systematically and regularly between fixed points soon followed. The trolley express serves the community in a way which is peculiar to its opportunities; in the small town or rural district it gives a quick and frequent service which neither the steam railway nor teamster can equal in flexibility, particularly in the

handling of meat, vegetables, and other perishable products. In some of the rural districts where the trolley express has been placed in commission, the standard of the country store has been sensibly improved on account of the facility with which goods ordered by telephone can be delivered locally. The opportunity to deliver the products of the farm at the city market within a short time after they are ready for shipment means a great saving to the rural community in both time and eliminated waste of fruit and vegetables; and it, therefore, insures fresher goods and better prices in the city itself. Combined with tunnel facilities for handling light freight in the congested districts of the largest cities, trolley express service should be capable of practically equalizing the purchasing power of money in the city and country.

ONE of the pressing problems of the near future for all the great naval Powers is the provision of docks adequate for the large ships which are now being constructed. Though the advocates of men-of-war of moderate dimensions may urge a policy of caution, the fact remains that the admiralties of the world are intent upon constructing vessels of ever increasing size. This remark applies not only to battleships and armoured cruisers, but also to the smaller vessels specially designed for torpedo warfare. The earliest British submarine was a small vessel displacing 120 tons. The latest development of the type displaces upwards of 300 tons. Again, the latest torpedo boats are larger than the torpedo boat destroyers of a decade or so ago, and the most recent destroyers now approximate in displacement to third-class cruisers, for the *Swift,* the 36-knot vessel which is being built for the British Fleet by Messrs. Cammell, Laird & Co., with an indicated horse-power of 30,000, is estimated to have a displacement of 1,800 tons. The outcome of this tendency is that the existing docking accommodation, even in British yards, will in the near future be very seriously taxed in spite of the fact that in the past ten years or so 125 old vessels have been struck off the active list. The same problem of dock accommodation will demand consideration at the hands of all the naval Powers of the world. While the existing docks may serve for the smaller cruisers and torpedo craft, the older of which, if adequately worked, are in and out of dockyard hands with great frequency, the existing provision for large armoured ships which are now being laid down will prove quite inadequate. In the design of the type of ship typified by the *Dreadnought* constructors have been compelled to limit the draft in order to enable the ships to be navigated in safety in shallow waters. The British authorities have had to keep in view two limitations. In the first place, the new ships have had to be designed so as to clear the shallows in the North Sea, and again they have had to bear in mind the lesson which was enforced when the battleship *Victorious,* though of only 14,900 tons displacement, became fixed in the Suez Canal. It is essential that British men-of-war should be able to roam the North Sea and take the short cut to the Far East by the way of the Suez Canal. Consequently a persistent effort has been made to keep down the draft of the latest battleships as much as possible. While the *Majestic* class of battleship of ten years ago drew, like the *Royal Sovereigns,* 27½ feet of water, in the case of the *Implacable* class this was reduced to 26½ feet, and in the *Dreadnought,* on a displacement of 17,900 tons, the mean draft has been brought down to 26½ feet. That has only been possible by greatly increasing the length and beam. The consequence of this tendency is that the *Dreadnought* is 490 feet long, or only 10 feet less than the *Powerful* and *Terrible,* while her beam is 82 feet, or 7 feet more than

in the case of the battleships of the *Majestic* class and 4 feet more than in the *King Edward VII.* design. In the construction of ships in other fleets the same tendency is observable. In the Japanese battleship *Setsuma* the length is a little less, but the beam runs to 83½ feet, while in the two ships authorized this year by the American Congress, though the draft has been kept down to 27 feet, the length is 510 ft., with a beam of 85½ feet. These two vessels of 20,000 tons rank at present as the longest and broadest ships hitherto designed. They mark the tendency of naval construction. High speed demands a long ship and stability for accurate gun fire requires a broad beam, while for reasons already enumerated it is unwise to increase the draft of water. It must be apparent that such an expansion in size is bound to lead to very heavy expenditure in the provision of docks, for there are comparatively few docks which can accommodate ships of this great size. This development in naval construction is consequently calculated to cause very anxious thought to the naval authorities throughout the world.

FOR the present the British Fleet is fairly well provided with large docks. Owing to the recent completion of the dockyard extension scheme at Devonport, at a cost of about five millions sterling, there are now in the British Empire thirteen Government docks and six colonial and private docks which can take the *Dreadnought,* and there are five other Government and two private docks in the United Kingdom as well as two colonial docks which can accommodate the *Lord Nelson* battleships, which are 80 feet shorter and 2½ feet narrower than the *Dreadnought.* It unfortunately happens that most of these docks are situated on the south and west coasts of the United Kingdom, while the strategical situation has led the Admiralty to concentrate a large proportion of the battleships of the Empire, and all the latest and largest ships which are responsible for the present difficulty, on the east coast immediately opposite to Germany. For six years past the Admiralty have been considering schemes for the development of a dockyard at Rosyth, on the Firth of Forth, but they are still merely marking time, and gradually plans have been cut down in order to avoid the spending of a large sum of money upon bricks and mortar at a point which is actually further removed from the German North Sea coast than Chatham and Sheerness. It is evident from answers that have been given in the House of Commons that the Admiralty regard an outlay of even two millions sterling with regret, and there is a widespread impression that eventually the scheme of development at Rosyth will be still further reduced. The idea is that the British authorities will imitate the forward policy initiated with so much success by the American Navy Department in the case of the *Dewey* and will construct several large floating docks which can be moved from point to point in accordance with the strategical necessities of the moment. The same problem of docking accommodation for these huge ships will have to be solved by all the great naval Powers, and where sufficiently sheltered waterways can be secured many arguments can be advanced in support of the policy of movable docks, apart from considerations of economy. This tendency on the part of the British authorities has already found expression in the construction of a large number of mobile repair ships for the torpedo flotillas and in the provision of a floating dock for submarines which has been built by Messrs. Vickers Sons & Maxim, at Barrow-in-Furness, and will be towed to one of the bases either on the south or east coast, most probably the latter. Another step in the direction of increased mobility has been taken. There is now nearing completion at Sir J. Laing & Sons yard at Sunder-

land a remarkable ship called the *Cyclops*, which may be styled a sea-going dockyard. This vessel has a displacement of 11,300 tons at a load draft of 21 feet. She is 460 feet long with a draft of 55 feet, and the machinery which is being supplied by Messrs. Richardson, Westgarth & Co., Hartlepool, is expected to give a speed of 12 knots. For armament the *Cyclops* will carry only ten 3-pounder quick-firing guns as a means of defense against attack by torpedo craft. The interior of the ship resembles a concentrated dockyard. The *Cyclops* is being equipped with carpenters', blacksmiths', and armourers' shops, and a large foundry where new castings can be made. The vessel is also provided with equipment for dealing with electrical work and has a coppersmith's workshop, and she is also being fitted with a travelling crane. Such a vessel as this will prove invaluable as a fleet auxiliary, and the confidence which the Admiralty have in this solution of the difficulty of carrying out repairs without going into dockyard hands may be judged from the expedition which has been shown in converting the distilling ship *Aquarius* into a repair ship for service with the Home Fleet and the expenditure which has already been incurred in adapting several old large cruisers to the same use. With a number of these mobile dockyards and less ambitious repair ships and several large floating docks the Admiralty will be able to meet the necessities of the Fleet whatever its distribution with far less difficulty than if they continued to devote large sums to the expansion of existing dockyards or to the creation of new ones. At the same time these dockyard ships and floating docks will not entirely solve the problem which has been forced to the front by the construction of ships of the largest size, and though for the present the British Admiralty may be content to sink comparatively small sums in bricks and mortar, other countries will have to face very large expenditure.

IN Germany it is already realized that the new policy of big ships which has been adopted will lead to a very heavy outlay in other directions. Large sums are already being spent in order to enlarge the docks which have hitherto served for battleships of 13,000 tons, and at the same time active steps have been taken in order to remove the silt in the principal naval harbours and fit them to give accommodation for the large vessels. At present Germany possesses no battleship or armoured cruiser intended for service in home waters drawing more than $24\frac{3}{4}$ feet, except the older vessels of the *Kaiser* class, built at the end of the last century, which were given a draft of $25\frac{1}{2}$ feet. The naval authorities evidently had reason to regret the depth of water drawn by these ships, for in later designs, though the displacement increased, the draft of water was reduced by a foot at the expense of the length and, to a greater proportionate degree, of beam. So long as Germany was satisfied with vessels of about 13,000 tons the docking problem could thus be eluded, and now that she is embarking upon the construction of ships rivalling the *Dreadnought* in size, she has been compelled to face the ever increasing expenditure not only upon docks but upon the Kiel Canal. This last item will add very considerably to the actual outlay upon the new battleships which are expected to have a displacement of about 18,000 tons, and the large armoured cruisers which are about to be built of almost the same size. The first step having been taken in ordering the ships, the German authorities have now been compelled to lay before the Reischstag a great scheme for enlarging the Kaiser Wilhelm Canal. This artificial waterway is the strategical link between the North Sea and the Baltic, and at present it is too small for the passage of men-of-war of the latest type. Until the canal is widened and deepened the German Fleet, so far as ships of the largest types are con-

cerned, must continue to be divided into two sections which can be united only by the long sea voyage round Denmark. The bill which has been laid before the Reichstag proposes to provide a depth of 37 feet with a breadth of 147 feet, or twice the breadth which is possessed at present. The sides will slope up from this breadth to one of 340 feet, an increase at the water surface of upwards of 100 ft. The scheme of enlargement has been planned on generous lines in order to provide for possible future developments, and provision has been made for a number of passing places. These will be provided at intervals of somewhat over 6 miles. Four of the passing places will be so large as to enable a fleet when partly through the canal in one direction to turn if necessary and retrace its steps so as to avoid being caught in a trap should an enemy succeed in blocking the exit from the canal. The locks at Brunsbuttel and Holtenau are also being greatly enlarged and are being given a depth of 46 feet, so as to enable ships of deep draft to enter when low in the water through injury received in battle. An expenditure of about £11,000,000 will be incurred upon this work. In other words, about twice the sum is being spent upon enlarging the canal as was originally required for its construction. The fact that this project in engineering has had to be undertaken within twelve years of the completion of the original canal, sufficiently indicates one of the difficulties with which Germany has to contend in the latest development of her naval power. The German North Sea coast is unfitted for the use of a fleet consisting of deep draft units. For this reason the German Empire is compelled either to abandon its forward naval policy or sink fresh capital in surmounting the strategical difficulties with which nature has encompassed her, by the costly enlargement of the canal or by the more dangerous policy of the absorption of Denmark.

AMONG the various systems, more or less elaborate, of cost-keeping and cost-finding, which have found such extended place in technical literature during the past few years, the main object of effort appears to be the recording of the cost of manufacture of the product, so that the information may be available about the time that the article is finished. This information, assuming that it has been accurately determined, will then enable the manufacturer to know whether he has made a loss or a profit on the operation, or in the limited number of cases in which he is at liberty to fix the selling price, it will tell him what that selling price should be after the desired profit has been added.

As a matter of fact, the manufacturer is very rarely in a position to fix his own selling price. In nearly every instance he has to meet a market price, determined either by the selling prices of his competitors, or by the extent to which the customer needs the article; and, in actual practice, the price which can be got for a manufactured article is, in very many cases, the predetermined element, to which all other efforts must ultimately be referred.

This being the case, it appears that most of the methods of cost-keeping begin at the wrong end. The manufacturer starts with a market for an article, otherwise he would not engage in making it. He also starts with a market price, which he must meet or fail to make sales. It must also be assumed that he expects to make a profit, since that is the sole object of conducting a business. The logical method, therefore, would appear to be to deduct the desired profit from the selling price, and thus obtain a manufacturing cost, which must not be exceeded. In nearly every instance the value of the material in the article can be closely estimated and the remainder represents the maximum amount which can be permitted for labor and expense charges. The true method of cost

finding, therefore, would seem to be to examine all the mechanical operations which are involved in the manufacture, and determine their cost by comparison with the known costs of similar amounts of boring, turning, planing, fitting, etc., also estimating upon a time basis, or other reliable method, the proportion of expense charge which the article can properly be expected to bear. The work of the cost department thereafter should be, not the mere determination of the cost of the work, but such a strict supervision as shall make sure that these predetermined figures are not exceeded. If the estimates have turned out to be wrong, the information thus obtained will serve as a guide for redesigning the article to bring it within the necessary cost limits, or, in some cases they may show that it cannot be manufactured at a profit at all, a fact which may have to be faced, but which is far less likely to be met if the problem is attacked in this manner than if the whole question of cost, expense, and possible profit are determined in the reverse order.

THE question of by-products and their utilization is one which has been discussed many times and from various viewpoints. There is no doubt that too much effort may be made to save the last fragment of material or power, and that the cost may be out of proportion to the saving. There are examples, however, and these are multiplying, in which modern technical developments are showing that what was formerly considered a by-product may hereafter turn out to be the principal source of revenue, while the original product of a process is relegated to the second place.

Thus, in our leading article in this issue, Dr. Hart shows that it is altogether possible that the exhaust steam in a power plant may be of more value in the production of cold by the absorption process than in the development of power in condensing engines. There is no doubt that in the modern power plant extensive and costly methods are employed for the sake of getting the maximum amount of power from the steam, these including feed-water heaters, superheaters, condensers, multiple-expansion engines, etc., and these are all fully justified if mere economy of steam is the ultimate end in view. The real aim of all mechanical improvement in such a plant is the economy of money, and any other saving must be regarded as a means toward that end, and it is quite possible to save steam at the expense of increased charges for wear and tear, depreciation, and interest on first costs.

If, under these conditions, it is found that the absorption system, using large quantities of steam, be found desirable from a commercial point of view, it is not impossible that the suggestion of Dr. Hart may become a reality, and that the refrigerating plant may have power to sell as a by-product, or rather that both power and cold may become joint products of a modern central station. Such a station would be distinguished by the simplicity of its power generating machinery, and possibly also distinguished by the satisfactory returns which it would make to its shareholders.

AT the recent engineering conference, held in London under the auspices of the Institution of Civil Engineers, one of the most interesting subjects for discussion was that brought out by the paper of Professor Rateau upon the development of the turbo-compressor for high air pressures. It is now well understood that one of the essential elements in the successful development of the gas turbine is a powerful rotary air-compressor of high efficiency. The gas turbine demands, by its very principle, the delivery of a continuous flow of air into a combustion chamber, at a pressure which must naturally be higher than the

pressure evolved in that combustion chamber. This can be successfully accomplished by the use of a reciprocating air compressor, but the very use of such a machine, however efficient, nullifies the value of the turbine, since the very reason for the attempts to produce a gas turbine is the desire to avoid the objections to the reciprocating machine. Probably the use of the combustion cylinder of a gas engine as its own air compressor on the alternate strokes represents about as efficient a compressing arrangement as can be devised, but when it is proposed to design a gas turbine, having its own action entirely rotary, it is evidently necessary that the air supply should be delivered by a similar rotary machine, and preferably one capable of operation at such a high speed as will admit of direct connection to the turbine.

Professor Rateau began his experiments as long ago as 1899, and a trial machine then showed that a single wheel, running with a peripheral velocity of 250 metres per second, gave an efficiency of 73 per cent.

By combining several such machines in a series it is found possible to multiply the pressure, much in the same manner as with the multiple centrifugal pumps for high lifts. With a single wheel a pressure of about half an atmosphere can be produced, but with multiple machines pressures of 6 to 7 atmospheres have been secured. The practicability of the apparatus is assured by the fact that fifteen such machines have already been constructed, in sizes ranging from 800 to 2,000 horse power, these being in successful and satisfactory operation. Professor Rateau believes that such compressors are directly applicable to blast-furnace work, directly superseding the large slow-moving blowing engines now used, but apart from this obvious use there are innumerable uses to which such pressure blowers, or compressors, may be applied, one of the most obvious being the supply of air to the gas turbine as above noted.

IT has often been stated that obvious methods of design and operation are often passed over in favor of more complicated and less desirable ones, and nearly every engineer knows that when the first example of a new device is before him he sees at once how greatly it may be simplified. A notable example of such a process appears in the almost complete supersession of the steam hammer for the forging press, especially for heavy forgings.

James Nasmyth was led to the invention of the steam hammer by the necessity of finding some machine better than the old trip hammer for forging the large shafts demanded for the paddle steamships then coming into use, and he describes, in his interesting autobiography, just how the idea of the combination of a steam cylinder and vertically-moving ram developed in his mind. For more than half a century this idea was followed by machine builders in Europe and America, and the great steam hammers at Creusot, in France, at the Bethlehem Works, in the United States, and in the Krupp Works, and elsewhere, are well known. Then, almost without any especial reason, it began to be observed, that pressure might be better than blows, and the forging press almost immediately superseded the hammer, and so promptly was this done, that the great hammers were scrapped almost as soon as they were completed, or else allowed to stand as relics of a past which seemed almost remote, although it was so recent. Yet the hydraulic press had been designed and constructed by Bramah before Nasmyth ever planned his first steam hammer, and was surely well known to him. During the lifetime of Nasmyth's patents the hydraulic press was at all times available for the use of any one who might have chosen to use it as a machine for forging, free of any monopoly. Not until the long life of Nasmyth was ended, and not until after great sums had been expended in the construction of ham-

mers of mammoth size did engineers turn to the quiet, powerful, and effective machine which had been at their disposal all the time, and apply, almost without modification, the hydraulic press of Bramah to a department of work to which it now appears to be adapted above almost any other.

It is possible that in other departments of machine design similar facts exist, and that many of the complicated and elaborate machines now in active service are ready to be replaced by simpler and at the same time more effective appliances. There are few machines whose effective life is longer than the duration of their patent protection, but those few form fundamental appliances with ever widening applications.

IN considering the question of the congestion of traffic in large cities, there appears to be no good reason why the problem should not be made subject to the same laws which are known to apply to the free movement to other bodies besides those of living human beings. When an engineer designs a system of mains for the flow and delivery of water he is most careful to proportion the various diameters with due regard to the volumes and velocities there obtaining. Especially is he careful to avoid any undue constriction in any of the passages, while opposing and counter-currents are things known to be impracticable and not permissible. In like manner the designer of a steam engine knows that he must give ample port area and must so arrange the steam passages that no obstruction or excessive friction may occur.

When, however, a transport system for people is designed, these obvious principles appear to be largely ignored, and while due attention is given to the movement of trains and the handling of cars, the passengers, the very element for the transport of whom the whole scheme is intended, are either left to themselves, or more often necessarily directed into channels in which the vigorously opposing currents cannot be avoided, and in which wide passages converge into contracted portals, utterly inadequate to the duty demanded, and altogether in ignorance of any of the physical laws of the flow of matter. That such arrangements would be considered as wholly unworthy of any steam or hydraulic engineer in providing for the flow of liquids or gases is evident, and yet such plans are adopted and put into construction, and then complaints follow because of the crowding and the delays.

Congestion in the transport of people also naturally occurs because of the periodic nature of the service. There is no congestion in a traveling belt conveyor, nor in its analogue, the traveling platform, because the materials and the passengers are carried along as promptly as they are delivered. Check the movement for but a few minutes, however, and there is produced a congestion which it may take much time to clear away.

Except in the case of the traveling platform, it does not yet appear just how absolute continuity can be attained in the transport of persons, but the nearest approach which can be made to it would go far toward removing the congestion existing in many great cities. Trains operated at a maximum frequency, clearing platforms before they have time to become seriously crowded, together with the adoption of every possible method of expediting the movement of people in mounting and alighting, these would go far toward increasing the efficiency of existing transport facilities.

Especially should all conflict of currents of humanity be rendered impossible, while the bottle-neck arrangement, whereby invitingly wide entrances lead up to narrow and inconvenient gates, should be replaced by full and free access to the right points, the flow being always in the

one direction, and opposing movements rendered impossible.

It might be interesting to determine the maximum possible efficiency of existing means of transport, and then make comparison of this with the actual results. There is little doubt that the efficiency of such installations as the New York Subway and of certain portions of the surface and elevated systems would be found so low that no engineer would be willing to accept the responsibility for such a waste of mechanical and commercial effort.

ANOTHER element in the improvement of transport facilities to which insufficient attention appears to have been given is found especially in the terminal stations of great railway systems, as well as at the docks and landing piers of steamship lines. These great transport systems appear to think that their duty is done when the passenger has been brought within a reasonable distance of the so-called terminus, and that when he, with his impedimenta, is deposited on a platform or pier, often nearly a quarter of a mile away from the actual outlet, in the midst of a confused crowd, that he has actually been brought to the haven where he would be.

If, instead of this unceremonious dumping of its passengers upon a remote platform, a railway so arranged its terminal station that the trains passed by the landings parallel to the lines of tramways, omnibuses, and cabs, rendering it necessary for the alighting passengers to cross the platform only to find means of immediate exit, much of the time both to the train and to the passengers might be saved. Such an arangement, indeed, is planned for the New York Terminal of the Hudson Companies tunnels, the trains passing around a number of loops, with platforms between, the cars being emptied upon one side and loaded on the other, without conflict or opposition, and the platforms being cleared by elevators. There are numerous methods by which the clearing of terminal stations from arriving passengers might be accomplished, and the real difficulty appears to be, not in devising plans for doing it, but rather for causing any one to feel that it need be done by any other method than by the active exercise of the passengers' own efforts.

The fundamental principle in this, as in other methods for removing congestion in transport, lies in the replacement of the present widely intermittent movements by such action as shall most nearly resemble a continuous flow, and a full realization that every interruption of continuity forms the inception of a congestion point, and such a congestion, when once produced, is continually more and more difficult to overcome.

CUMMINGS C. CHESNEY

A BIOGRAPHICAL SKETCH

CUMMINGS C. CHESNEY, first vice-president and chief engineer of the Stanley-G. I. Electric Manufacturing Company, of Pittsfield, Mass., is a Pennsylvanian by birth. He entered the Pennsylvania State College in 1881, and was graduated therefrom as a chemist four years later, after which he spent three years in teaching at the Doylestown Seminary and Pennsylvania State College.

In 1888 Mr. Chesney joined William Stanley's loboratory force at Great Barrington, Mass., where he devoted himself particularly to experimental chemistry and to electrodynamics. The following year he went with the United States Electric Lighting Company, in Newark. In 1890 he removed to Pittsfield, Mass., where he was one of the original incorporators of the Stanley Electric Manufacturing Company. He also continued one of the members of the Stanley Laboratory Company.

After the incorporation of the Stanley Electric Manufacturing Company it soon became apparent to those associated with Mr. Chesney that his broad general knowledge and clear, conservative judgment indicated him as the man to guide the electrical departments of the manufacturing establishment, and the future demonstrated that this estimation was not at fault. As the company's chief electrical engineer, with his associates and staff of assistants, Mr. Chesney early perfected the inductor type of revolving field alternator to a point far beyond anything before reached in this country and not surpassed in the world. To him likewise is due the credit of having laid out the first polyphase power transmission plant to be put into successful operation in America. This plant is at the present day supplying light and power for use in the towns of Housatonic and Great Barrington, Mass. When Mr. Chesney and those around him contended that alternating-current generators could be run in parallel under conditions prevailing in practical operation, their ideas were scoffed at by almost all other American engineers of standing. To-day, however, the paralleling of alternators has long since passed the theoretical stage. When others were ready to prove that the winding of 10,000 to 12,000-volt generators was an impracticability, Mr. Chesney designed alternating-current generators for such voltages with great success.

When it became apparent that transformers of large capacities would be a valuable addition to the electrical plants of the time, notwithstanding predictions to the contrary by those presumably in a position to know, he, with his associates, again realized their convictions in a most satisfactory manner, and to him is due the design of the first commercial 100-light transformer ever used in this country. This transformer was made by the Stanley Electric Manufacturing Company in 1891. A long list might be given of electrical developments in which Mr. Chesney has been a pioneer. Among other work, switchboard instruments, high-tension arc-breaking devices, frequency indicators, indicating wattmeters, lightning protection for high and low-tension circuits, and many other appliances have all had a share of attention, and always with satisfactory results.

He is a member of the American Institute of Electrical Engineers, the Engineer's Club, and a director in a number of electric lighting and power companies throughout the country.

ROBERT FULTON

FROM THE ORIGINAL PAINTING BY HIMSELF IN THE POSSESSION OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

(See page 405.)

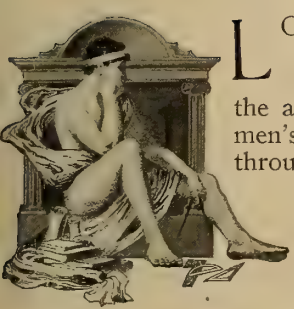
INDEXED

CASSIER'S MAGAZINE

VOL. XXXII SEPTEMBER, 1907 No. 5

THE ENERGY PROBLEM OF THE UNIVERSE

By A. H. Gibson, M. Sc., A.M.I.C.E.



LOOKING backward, and tracing step by step through the ages the evolution of men's ideas and aims through varying social conditions, we find that in its essentials one idea—that of what comprises wealth—is still the same as when Neolithic man, armed with hatchet of stone and arrow head of flint, measured his wealth by a standard of just such implements.

Examining the state of affairs more closely, we find that in every age and in every state of society, the real standard of wealth has been the store of available energy, or the potentiality for obtaining possession of such a store, possessed by a man or a nation.

The prime mover—the means by which this energy has been converted into useful work directly providing a livelihood for its possessor—has taken many forms, and it may be interesting, before considering the form or forms to which evolution may ultimately tend, to consider briefly the stages through which it has already passed.

And first, looking backward into distances so dim and remote that even tradition fails to give us more than the barest outline of social conditions, we find that man—the first of all prime movers—transformed in himself—the most perfect and efficient of machines—the energy of red deer and mastodon into the twang of the loosened bowstring and the shrill whistle of the arrow flying through the air on its deadly mission—the accumulation of more energy. Here stores of food and of weapons, with their consequent effect on health and on the ability to follow the calling of a huntsman, formed the basis of wealth.

So, a little later, as historical periods go, we find man, now living a pastoral life, translating in himself the energy of corn, of wine, and of oil, into the furrowing of the plough land, the sowing of seed and the reaping and garnering of the produce of his fields. A little later on comes the utilization of the energy of the domestic ox or ass for the same purpose, or for turning the wheel which irrigates the land hitherto barren and thus render available the energy which though latent all the time only needed this to make evident its potentiality to produce crops.

Coming in point of time to the middle ages, we find that ideas have changed somewhat outwardly, though not in essentials, and he is now rich who owns land—rolling acres of pas-

 Copyright, 1907, by the Cassier Magazine Co.

ture and woodland, tillage and glebe; capable of supporting a small army of retainers to do the bidding of its lord; an army capable, in virtue of the doctrine that might is right, of accumulating by courtesy of long bow and of pike, the store of energy of some weaker neighbour to its own master. Historically before this time, however, came the utilization of the energy of the winds—perhaps the first source of directly available energy to be tapped by man—driving ships across the seas and rendering available stores of energy till then undreamt of. Then the discovery that the energy possessed by the flowing stream of water as well as by the moving air, could be utilized to work rude machines, until at last, seeming of small importance at first, but looming larger and larger on the horizon of men's minds as time went on, came the discovery of the availability of the energy possessed by the vessel of water when heated by a fire of wood or of coal.

And as we come to more modern times we see that available energy, or the power to obtain this, still forms the standard of wealth, and with this in view man is striving with feverish energy to obtain from Nature some of that store which in the early days of creation a far-seeing Providence either safely locked away against a more imperative demand, or placed ready to man's hand—the energy of the coal field—of the petroleum deposit—energy stored in the waterfall and even in the ocean waves. Wherever man increases his share of the available energy of the world there does he become rich, perhaps more so now than at any previous periods of the world's history.

Before considering what may in the future become the sources of energy most suitable for utilization in all, or in some particular cases, it would be well to examine the present known sources, with a view to noting the extent to which they have been drawn upon in the past; their present possibilities; and the likelihood of their satisfying our future needs.

Neglecting (as being at present outside the scope even of prophecy) the fascinating possibilities of radium as a source from which an almost inexhaustible supply of energy may be obtained, we note that the energy of the universe, as available on earth, may be roughly classified under four heads.

1. Energy leaving the sun and reaching the earth as radiant heat and as light—unstored.

2. Heat energy stored in the earth, and available because of the high temperature of its interior.

3. The kinetic energy possessed by the earth in virtue of its diurnal rotation, and of which advantage may be directly taken by utilizing the rise and fall of the tides as a source of energy.

4. The energy which may be liberated when chemical combination takes place between the various elements or compounds to be found in the earth.

The energy of rivers and waterfalls being only available in virtue of the re-evaporation of water which has reached the sea, may be considered as coming under heading 1, while the energy of the wind may be considered as coming under headings 1 and 3, the current of air being due, partly to the sun's heat, and partly to the earth's rotation.

The radiant energy of the sun has been in the past and must always be, indirectly perhaps, the chief source of terrestrial energy, producing as it does the heat and light necessary for all plant and animal life, and to this extent all energy now stored in the coal fields and petroleum deposits must be attributed to this cause. In primordial days, then, this was the ultimate source of all energy available by mankind.

The direct utilization of this radiant energy as a source of power is, however, a different matter. It has been attempted by several inventors, with some measure of success, particularly in California, where, by us-

ing huge parabolic reflectors driven by clockwork so as to have their axes always pointing towards the sun, and each carrying a steam boiler at its focus, power has been obtained; an installation fitted with a reflector of 33 feet 6 inches diameter developing just over 2 H. P. under favourable conditions. By using the engine to charge an accumulator or to pump water into an elevated reservoir, a fairly steady supply of energy may be obtained in suitable weather.

The results of repeated experiments with similar apparatus show that, between the equator and latitudes 45 degrees N. and S., with a clear sky, quite 3.5 British thermal units per minute can be obtained for 9 hours per day for each square foot of projected area perpendicular to the sun's rays. Could all this heat be utilized, this would give 8.2 H. P. for each 100 square feet of projected area, but, due to the thermodynamic inefficiency of the prime mover only about 12 per cent. of this, or about 1 H. P. for each 100 square feet of surface, is available as indicated work in the engine cylinder.

The disadvantages inseparable from the utilization of this source of energy on any but the smallest scale are very great, both on account of the initial high cost of installation and of maintenance. These must always be high, since climatic and meteorological conditions prevent the installation of single plant of more than moderate size, and comparatively small power. Again, those parts of the earth's surface where a fairly steady supply of such energy could be relied upon, are, on account of their excessive heat, and their freedom from rain, quite unsuitable for the maintenance of any large centres of industry, while in temperate climates, or in subtropical climes where the rainy season may cause a total stoppage of the power supply for some months on end, the method is obviously impossible. On these several counts it would appear that not until every other practicable source of energy has been tapped, will the direct utilization of the sun's radiant energy be carried out on any large scale. With the improvement of high tension transmission of electricity, for long distances, however, the idea of a series of power stations stretching along the southern coast of the Mediterranean, and along both sides of the Nile Valley, as well as along the shores of the Red Sea and supplying power through high tension transmission lines to centres of industry in Upper Egypt and Southern Europe, becomes more feasible. Taking an available area of say 20,000 square miles, and assuming 25 per cent. of this area to be usefully applied to the abstraction of solar energy, there would be available, on the basis of one horse power per 100 square feet of surface, no less than 150 million horse power for 9 hours a day, an amount of energy which, when taken along with that from other subsidiary sources, would go far towards satisfying the entire power demand of the world.

Considering next the energy stored in the earth, in virtue of the difference in temperature between its interior and its surface, no attempt has yet been made to take advantage of this on any large scale, and it would appear on examination that this source of energy, though at first sight most promising, must be definitely acknowledged as being of no avail in solving the future power-problem. It is true that at isolated points of the earth's surface—notably in the Yellowstone Park in the United States of America, and in Iceland, as well as in the northern districts of New Zealand, abundance of water at a temperature of say 200° F. is brought to the surface by hot springs and geysers, and in close proximity to water supplies at a much lower temperature, say 60° F., and in these few instances there is no reason why this difference in temperature, though too small to allow of an engine using steam as its motive fluid to be used, should not be utilized to work a motor using either

vapour or carbonic acid gas, the boiler being heated by the hot water supply, while the condenser is cooled by the adjoining cold supply. But these are only isolated cases. Normally, after a depth of about 100 feet is reached, the increase in temperature as the earth's centre is approached, is found to be at the rate of about 1° F. for each 60 feet in depth, this temperature gradient increasing slightly with the depth. Until the former depth is attained the annual fluctuations of temperature are still felt. It would thus be necessary to sink a bore hole to a depth of 6000 yards to reach a point whose temperature was say 380° F.

In favourable localities, in the neighbourhood of volcanoes, or where the earth's crust is known to be thin, this depth would of course be considerably reduced, but unfortunately such localities, on account of the probabilities of earthquake shock, and of volcanic eruption, are not exactly advisable places for the establishment of large centres of population or of industry. Could a supply of cold water then be introduced by one bore hole into a large natural or artificial cavity at this depth and led away at a higher temperature through a second bore hole, these two water supplies might be utilized as before, for the working of either ether vapour or carbonic acid engines. But, assuming this temperature at the base of the bore hole to be initially attained, directly the flow of water commenced, the temperature would be lowered, and finally, when a steady state was attained, only as much heat would be given to the water as could be transmitted by conduction through that portion of the earth's strata in contact with the water. Assuming, when this steady state was reached, a temperature gradient of so much as 1° F. for 10 feet, we should get a supply of heat by conduction of about 0.12 B. T. U. per square foot of surface per hour and thus a cavity whose internal area was 237,000 square yards or say 260 yards in diameter, would be needed to give a supply of heat, equivalent—with a perfect engine—to 100 H. P.—giving, with the engine in use probably about 10 H. P., certainly an inadequate return for the energy expended in sinking the bore holes alone. Here, too, the excess of the loss of heat by conduction from the surface of the ascending bore hole, over the gain by conduction from that of the descending bore hole has been neglected, though this would probably reduce the available energy by one-third, the issuing temperature of the water probably not exceeding 200° F. From this it would appear that, except possibly in the few localities before mentioned, the direct utilization of this energy is quite impracticable on any commercial scale. It must not be lost sight of, however, that in virtue of its conduction to the earth's surface, this energy is being continually utilized in the production of foodstuffs and so must always play a large part in the energy scheme of the globe.

Considering next the energy of the winds, we see that this is useful for small powers and for work in which regularity of working is not essential, such as for pumping and drainage operations, flour milling, etc. Yet for large powers the installation becomes unwieldy and expensive, out of all proportion to the return. The further fact that this source of energy cannot be depended upon, and the difficulties in storing energy so irregularly produced, effectively militate against the utilization of this source of energy on any large scale.

On the other hand, waterfalls and rivers afford a source of energy which is equally suitable for large or small powers, and is suitable for all purposes, being steady, continuous, and not involving great expense for machinery and appliances. Undoubtedly this will, in the not distant future, become perhaps the second most important source of the world's energy, and indeed probably the next fifty years will see the harnessing of

every cataract of any size, whether near or remote from the industrial haunts of men, the energy so obtained being electrically transmitted to the nearest centre of industry if not actually utilized on the spot.

This points to the ever-increasing development and use of the turbine as a prime mover, the standard type probably, on account of its many advantages and high efficiency, developing either on the lines of the Francis inward flow turbine, or, for specially high heads, on the lines of the tangential impulse, or Pelton wheel.

The next source of energy to be considered is that due to the earth's diurnal rotation about its own axis. In virtue of this we have stored up kinetic energy whose amount at the present is in the neighbourhood of 3.7×10^{28} foot-pounds, but of which we can only indirectly avail ourselves. The effect of this rotation, combined with the gravitational effect of sun, earth, and moon, is to produce tides twice daily in the various bodies of water distributed over the earth's surface. If any considerable mass of this water can be entrapped at high tide, and allowed to escape through turbines or any other form of hydraulic motor, as the tide ebbs, evidently the work done is indirectly due to the earth's rotation, and will, if sufficiently great, have ultimately an appreciable effect in reducing the velocity of the earth's rotation, i. e. in increasing the length of the sidereal day. Since, however, the length of the day would only be increased by a fractional part of a second by the continuous abstraction of an amount of energy equivalent to ten million horse power for a million years, there would appear to be small reason for considering the effect of this on posterity.

The utilization of this energy may be carried out in two or three ways. For example, during the flow of the tide, water might be allowed to fill a large basin excavated to low-water level, this water being allowed to flow through a series of turbines as the tide-water thus impounded ebbs.

This might be done in either of two ways. The whole of the water might be stored until say one hour before low tide, and then be allowed to do the whole of its work during the next hour, the turbines thus working under a variable head having a mean value of about $\frac{H}{2}$ feet, where H is the total tidal range. The whole of this energy would then need to be stored by accumulator until required. A second and preferable method consists in allowing the turbines to work under an approximately constant head of say 3 feet, the water being allowed to flow as soon as the level in the storage tank is 3 feet above that of the ebbing tide.

Assuming a mean tidal range of 20 feet, in this case the level in the storage tank could only be allowed to fall through about 17 feet, and the work done, with a given area of storage tank, would be only about one-third that done in the previous case, though, owing to the time occupied in developing this power being about 5 hours as against 1 hour in the former case, the capacity for storage could be considerably reduced.

In addition, too, the fact of working at constant head would greatly simplify the problem of regulation and would tend to greater efficiency of working.

With an installation worked in this manner power would be directly available from the turbines for two stretches of $4\frac{1}{2}$ hours each daily, at intervals of about 8 hours, and obviously as these slack intervals will overlap the working time to a greater or less extent, a storage system would be necessary, capable of dealing with the worst combination of circumstances which might arise, and capable of carrying say 85 per cent. of the half daily output.

With a duplicate system of turbines, arranged to work under a constant head, one system being driven by the ingoing tidal water, and the

second system, as before, by the outgoing water, the work done by the water per day would be practically doubled, and it would now be possible to get useful work delivered from one or the other series of turbines for four intervals daily, each of about $4\frac{1}{2}$ hours' duration, and separated by idle intervals of about 2 hours. In this case, the capacity of the storage plant needed would only have to be sufficiently great to carry the plant over a two hours' period, or about 25 per cent. of that needed in the previous case.

This necessity for cumbrous storage systems forms the main drawback to either of the foregoing schemes. The necessity may, however, be obviated by the provision of duplicate basins divided by a bank in which the turbines are placed. If now the upper basin communicates with the sea during the higher third of the tidal range while the tide is rising, and if the lower basin communicates with the sea during the lower third of the range while the tide is falling, the upper level never being permitted to fall below $\frac{2}{3}$ *H.*, and the lower level never to rise above $\frac{1}{3}$ *H.*, the available head, at all stages of the tide, varies between about .53 *H* and .80 *H*, having a mean value of about $\frac{2}{3}$ *H*.

If the area of each basin be A square feet, a volume of water equal to $\frac{AH}{3}$ cubic feet may thus be allowed to pass the turbines in $8\frac{1}{3}$ hours, and, assuming a mean head of 20 feet, and a turbine efficiency of 75 per cent., this gives

$$\frac{AH}{3} \times 62.4 \times \frac{2H}{3} \times \frac{.75}{33000 \times 60 \times 8.33}$$

$= 6.3 \times 10^{-7} A H^2$ horse power

If A^1 = area in acres, this becomes:—

$.0274 A^1H^2$ horse power.

This might be increased by possibly 30 per cent. by allowing a variation of level in the storage tanks equal $\frac{H}{2}$, but the advantage would be largely counteracted by the necessity for larger and more costly turbines, and by the greater difficulties in succesfully regulating the speed.

In a scheme to be worked on these lines on the estuary of the Seine near Honfleur, the cost of special works necessary, not including the external training walls, which were necessary in any case for the improvement of the course of the river, worked out at £72,000, basins having a total area of 25,000 acres being inclosed. The tidal range being between 10 and 16 feet, this gives an available horse power of 3,400 at neap tides and 8,800 at spring tides, or, taking the smaller value as being constantly available, gave a capital cost of £21 per horce power, developed at the turbine shaft. On the mean power developed the cost becomes £11.8. per horse power developed. It would appear then that since the mechanical difficulties in the way are not very great, and since the financial side of the question is favourable even with coal at its present price, this method of utilizing the energy of the tides is not only feasible but most promising for the future, giving, as it does, an almost inexhaustible supply of energy, with absolute constancy.

Attempts have been made by numerous inventors to devise some means of utilizing the vertical rise and fall of the water in forming waves, and the energy contained in the water due to that motion, to perform useful work, and on a small scale several methods are feasible.

But on account of the variability and irregularity of the energy supply, and from the very nature of the case, it is evidently impossible that this source of energy can ever be utilized on any commercial scale.

Coming at last to the fourth, and most generally used source of energy, that of chemical combination, as exemplified in the combination of carbon and of hydrogen with oxygen, it is at once apparent that the more important of these sources of energy, the coal and petroleum de-

posits of the world, can remain available only for a further comparatively short period, as geological periods go, in the earth's history, and that as regards the distant future, they may at once be dismissed. Probably within the next 250 years the cost of coal will have increased to such an extent as to make the general utilization of some other source of energy essential. At present, however, it is, and in the near future is likely to remain, the most important source of energy for all motive purposes, and on this account it is worth while considering how its energy has in the past, is at present being, and in the future is likely to be most generally utilized.

In the past, practically the only method of utilizing this energy was in the production of steam, and it is interesting to trace the form of prime mover used for the transformation of the energy of this steam, in its slow development from the old reaction wheel of Hero and the water lifter of Savery, the atmospheric engine of Newcomen with the slow speed engine driving a rotating crank, the high speed Corliss engine of to-day, still the most efficient of all prime movers using steam as the motive fluid, and finally the steam turbine. It is now clear that all along, the ideal toward which evolution was tending, was the moderate speed motor, rotating with uniform angular velocity, which should at once be as simple in construction, take up as little space, and work as economically as posible. Seeing that this was the end to be aimed at, it is not surprising that, in virtue of the manifold and manifest disadvantages of the reciprocating engine, in virtue of reciprocation alone, the minds of inventors should, from the earliest days, have been turned towards the possibilities of the rotary engine, and it seems strange that this, the earliest type of steam engine, should have come to fruition so comparatively late in engineering history.

This, in its most recent form, the steam turbine, seems an almost ideal form of prime mover for the use of steam, because of its simple construction, the small space occupied, and, considering its comparatively recent development, its economy of working. Considering, too, the relative merits or turbines of the Parsons type and of the Curtis and deLaval types, it would appear that the advantages of the latter types, advantages due to better possibilities of governing economically under varying loads, to absence of "cylinder condensation," to reduction of weight of rotating parts, and generally to simplification of construction, will lead to a modification of one of these being finally adopted as the standard designs of the future, rather than that of the Parsons type.

But unfortunately all prime movers having steam as a motive fluid suffer from the common disadvantage that, in the production of this steam from water very great and unavoidable losses occur, while further and even greater losses occur in the transformation of this energy into useful work, only about 12 per cent. of the energy available in the fuel being available as useful work. In virtue of this consideration, it would appear at once that since the available store of energy accumulated in the form of fuel suitable for steam raising is so strictly limited, the steam engine, whether reciprocating or rotary, cannot, unless its efficiency be enormously increased in some way, hope to exist as a prime mover, unless, indeed, some other method of steam production is adopted. Now natural fundamental laws, together with the fact that the materials of construction at our disposal are not capable of being used at a very high temperature when in contact with steam, practically limit the possible thermal efficiency of a steam engine to about 65 per cent., while consideration of maintenance, lubrication, etc., limit this to about 50 per cent. But between this and the efficiency actually obtained in practice, there is a great

gulf fixed, a gulf, the bridging of which in theory is fairly well understood, but which is in practice impossible.

Turning from this to the consideration of the internal-combustion engine, we find many obvious advantages, and, in view of these, it is not surprising that of late years so much attention has been devoted to the development of this type of prime mover.

Here many of the losses and inconveniences inseparable from the use of boiler or separate steam generator are abolished, the furnace itself forms part of the cylinder, and losses of heat by radiation from boiler casing, from steam pipes—and along with flue gases are done away with. The heat is generated just where it is required, its rate of generation can be exactly regulated, and in practice this type of motor is found to be rather more economical and more efficient than the steam engine or steam turbine. This is due largely to the fact that the motive fluid, being a gas and not a vapour, does not liquify on being cooled, and that on this acount the losses of heat due to initial condensation in the steam engine cylinder, are obviated. The higher temperature limit of the internal-combustion engine cycle is conducive of more efficient working; but here again, a limit in this direction is early reached, due to the impossibility of constructing a reciprocating engine which shall work satisfactorily without lubrication and at a very high temperature. This necessitates water jackets, and a consequent direct loss of some thirty-three per cent. of the heat generated. Also the motor suffers from the necessity for changing reciprocating into circular motion, just as does the steam engine.

However, the balance of advantages pertaining to the internal combustion motor, whether using petrol, paraffin, alcohol, or gaseous fuel, blast furnace or producer gas, is such as to lead us to expect that the prime mover of the immediate future will be one having internal combustion, without the corresponding disadvantages consistent with reciprocating motion, and will be a machine of the turbine type.

It remains to consider, then, what must be the essentials of a satisfactory motor of this type.

A turbine of the Parsons or impulse type might be used, taking a charge of liquid or gaseous fuel, compressing and exploding this, using the high pressure gas thus obtained as a motive fluid, the working being impulsive. This method is most unsatisfactory for many reasons. The excessive temperatures involved inside the turbine casing would, as in the case of the reciprocating engine, necessitate water jackets. The great differences in pressure in the supply chamber, due to the explosive system of working, would effectively militate against any economy in working, and would cause great irregularity of rotation, though this might be obviated by the use of a reducing valve. This would, however, itself be another cause of inefficiency.

A second method of working would be to have a turbine of the Parsons type, using as its motive fluid the products of combustion of liquid or gaseous fuel, burned under a constant high pressure in a separate chamber, the method of working approximating to that of a steam turbine. Here, however, it would be necessary on account of the high temperature, to reduce this before entering the turbine, either by cooling by water jackets, or by passing the gas thus formed through water, a mixture of steam and gas then going forward to the turbine.

The first of these methods suffers from the disadvantage that almost 50 per cent. of the heat is wasted initially, while the second has the disadvantage that, while no condenser is possible, the lower limit of temperature of working would be 212° F., instead of 40° or so with gas alone, unless the latter stages of the

turbine were to be waterlogged. In addition the cycle is irreversible, and, thermodynamically, the whole process is very little better than that of the ordinary steam engine. The mechanical difficulties standing in the way of this method of working are considerable, and although many attempts have been made to overcome them, these have not met with any measure of success.

There is still another way of overcoming the difficulty. The gas may, as in the previous case, be produced at constant high pressure, and may be then led through diverging nozzles before passing into a turbine of the deLaval type. The gas is then expanded before entering the turbine, its pressure energy is turned into kinetic energy, and what in this case is most important, its temperature is so reduced by the expansion that on entering the turbine the temperature is within practicable working limit. The mechanical difficulties are not great, the chief being that of producing a constant supply of gas at a pressure of say 300 pounds per square inch. This, however, has been overcome. The machine would be light and of simple construction. Leakage in the turbine chamber would be immaterial—producer gas or any liquid fuel could be used. There would be no loss of heat by water jackets, small radiation loss, and this only from the produce. Regulation would be easy, and the whole system compact. In fact, the advantages are so many and great, and the disadvantages so few, that it would appear highly probable that this type of prime mover will be the standard of the not distant future.

But the energy of chemical combination may be utilized in still another way, as in the case of an ordinary electromotive cell, to give electrical energy which may be directly utilizable for useful work. But for the cost of suitable materials, which makes this method prohibitive on any but a small scale, this would present very many and great advantages over the usual cycle of operations with its change of chemical energy to heat energy, heat energy to mechanical energy, and mechanical energy to electrical energy, and its corresponding losses at each transformation. Were it possible to use carbon as the positive electrode of a voltaic cell, the consumption of this carbon producing an electric current, a much greater proportion of its energy would be turned into useful energy, and many attempts have been made to solve the problem, with some small amount of success. The difficulties arise from the fact that while carbon in the form of coke is a good conductor of electricity, yet it is electronegative to all but a few elements, and thus the choice of a suitable negative for the battery is limited. Also carbon is insoluble in all ordinary solutions. In spite of this, at least two methods of working, those of C. J. Reed and of Jacques, have overcome the difficulties, although in each of these cases a furnace with its accompanying consumption of fuel is necessary.

In view of the many difficulties to be overcome—of the low voltage available and of the cumbrous and costly construction necessary, it is highly improbable that any solution of the power problem will ever be found in this direction.

In conclusion, it would appear that for the present, at all events, and for such purposes as marine propulsion, where a highly concentrated supply of energy is essential, for some considerable time in the future, the energy latent in our coal and petroleum deposits will be that most widely drawn upon. As this supply becomes more and more exhausted, more use will have to be made of such sources of energy as are provided by our rivers and waterfalls, as a supplementary supply. Finally, as the cost of fuel becomes more prohibitive for power purposes, advantage will probably be taken, in suitable localities, of the energy of the tides, and also, in other suitable localities, of the radiant

energy of the sun's rays. As the second of these supplies is available with sufficient regularity only between latitudes about 40 degrees north and south of the Equator, and as all heating for domestic purposes will then, on account of high fuel cost, probably have to be done by electrical means, there will, in all probability, in course of time, be a general moving of the industrial centre of gravity of the earth's population to a point within these limits, where climatic conditions render artificial heat for domestic purposes to a greater extent unnecessary.

The prime mover of the future would appear to be in secular order, the steam turbine, the internal-combustion reciprocating engine, using producer-gas, and the internal-combustion turbine of the deLaval or Curtis type, the development of these going on side by side with that of the hydraulic turbine of the reaction or impulse type. Since the hydraulic turbine, to take advantage of tidal power, will have to work under variable and generally under low heads, the axial flow or Jonval type, on account of its general suitability for this method of working, will probably become more and more the standard type. Finally, as solar energy becomes more and more utilized, the steam turbine, certainly of the impulse type, will once again take the place of the now almost defunct internal-combustion engine or turbine. In every case the energy will in general be transformed and transferred or stored electrically until needed, and the success or otherwise of any future energy plant will, to a large extent, depend on the manner in which the transformation and transmission over long distances of high tension electricity becomes efficiently and easily possible.

For such purposes as marine propulsion and for aerial navigation, where a highly concentrated source of energy is required, putting aside the immense possibilities of radium or some such compound as a potential supply, it would appear that the internal-combustion turbine, having alcohol as its fuel, will finally become the standard motor.

The difficulties to be overcome betore this is accomplished, are very small, the alcohol motor is a commercial success, and it only remains for the high cost to drive natural fuel from the field, for the alcohol motor to be used for this class of work.

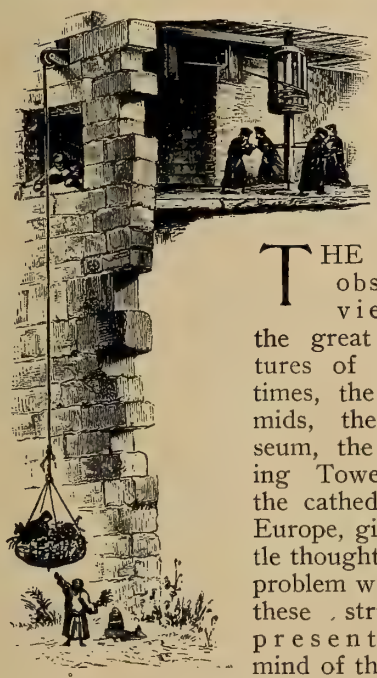
One fact is certain, that in the future the engineer, using the term in its widest sense, will become increasingly more and more essential to the social progress of the universe, and that on his labours and inventiveness, more than on that of any other class of society, will depend the ultimate physical well being of mankind.

As a factor in producing flux of physical activity and change in conditions of living and of physical boundary, his scope is far wider than that of the statesman or the soldier, and as time goes on a wider scope for his activities will not only be presented to him, but will be imperatively forced on him. On his endeavours will largely depend the ultimate distribution and social conditions of the human race, and when the millennium dawns and the history of mankind's progress is chronicled, will appear, far before those of statesmen and warrior, the names of such men as Newton, Laplace, Joule and Reynolds, men who have in a manner perhaps hardly ever realized by themselves erected sign-posts on the way to that Utopia in which the Energy Problem of the Universe shall have found its ultimate solution.

THE GROWTH AND DEVELOPMENT OF THE ELEVATOR INDUSTRY

By Charles H. Kloman, C. E.

The modern elevator has worked such remarkable changes in the architecture of many great cities that it is difficult to believe that it has been in use for a period of little more than a single generation. Mr. Kloman reviews rapidly the development of this remarkable industry, and shows the changes through which it has passed on arriving at its present stage of perfection. Even now there is reason to believe that important modifications are impending in elevator design and construction, some indication of which is given in this paper. We desire here to acknowledge indebtedness to the American Society of Civil Engineers for the use of illustrations originally prepared for the paper of Mr. Thomas E. Brown, presented before the International Engineering Congress at St. Louis, and also to Mr. Brown for valuable information.—The Editor.



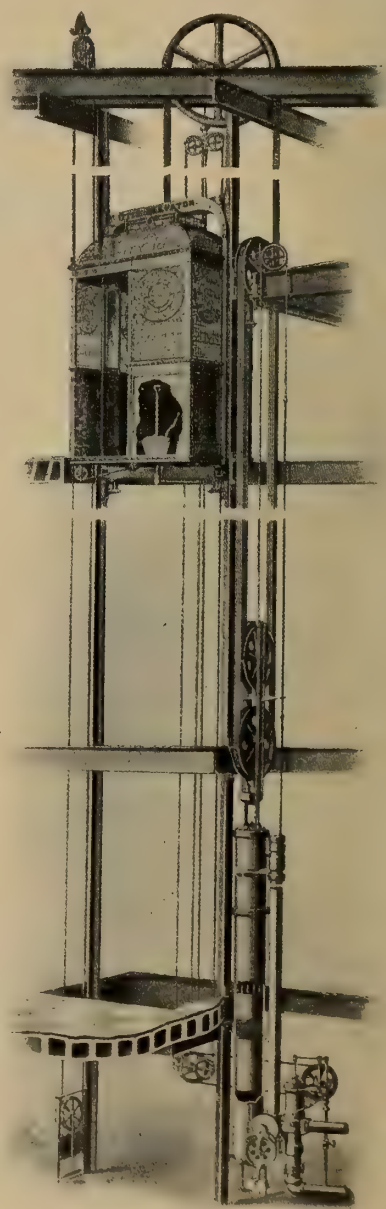
THE casual observer, viewing the great structures of ancient times, the Pyramids, the Coliseum, the Leaning Tower and the cathedrals of Europe, gives little thought to the problem which these structures present to the mind of the engineer, namely, what means were employed for raising to the required heights the enormous masses of material of which they are composed? It is a well-known fact that the builders of these structures possessed but the crudest of implements, the wedge and the lever, and relied upon great numbers of human hands, slaves and captives, to accomplish their purpose. From those early days to the present time there has been a steady and continual improvement in devices and appliances for elevating materials and persons. The application of horsepower to a winch, winding a cable, which passed over a sheave elevated on a wooden structure, suggested to the pioneers of the elevator industry the possibilities of utilizing the steam engine, and although it has been claimed that water power, both for actuating a wheel and for raising a plunger lift, was used in England and France some centuries ago, yet there is no reliable evidence at hand to prove these statements. The first power elevators introduced in the United States were manufactured about 1850, and were belt-driven, spur-geared, freight machines. The use of these was confined to factories, and it was not until about 1870 that an elevator for carrying passengers was suggested. The demand for such elevators was confined almost exclusively to hotels, and the first form was a winding drum driven by two steam cylinders. The noisy action of such machines, together with the vibratory motion of the car, led to experiments in other lines, telescopic plunger machines and large direct-driven screws passing through the centre of the car, an example of which latter could have been seen in the Continental Hotel in Philadelphia as late as 1874.

It was quite natural that the wonderful growth of the lower end of Manhattan Island should lead to a demand for extension of building operations up in the air, and consequently stimulate the inventive faculties of the elevator builder, and accordingly we find in the year 1880 two great buildings, regarded as wonders of the world, erected in New York and equipped with passenger elevators. These were the Western Union and the Tribune buildings, both originally equipped with direct acting steam elevator engines. In the Western Union building there was subsequently installed a water balance elevator, which consisted substantially of a large bucket attached by a cable, passing over a sheave above, to the passenger car and running in a separate shaft. This bucket was filled or emptied as the car was required to ascend or descend, by the operator in the car, and the safety appliance consisted in a brake automatically applied by the operator. This elevator continued in operation until the partial destruction of the building by fire about fifteen years ago.

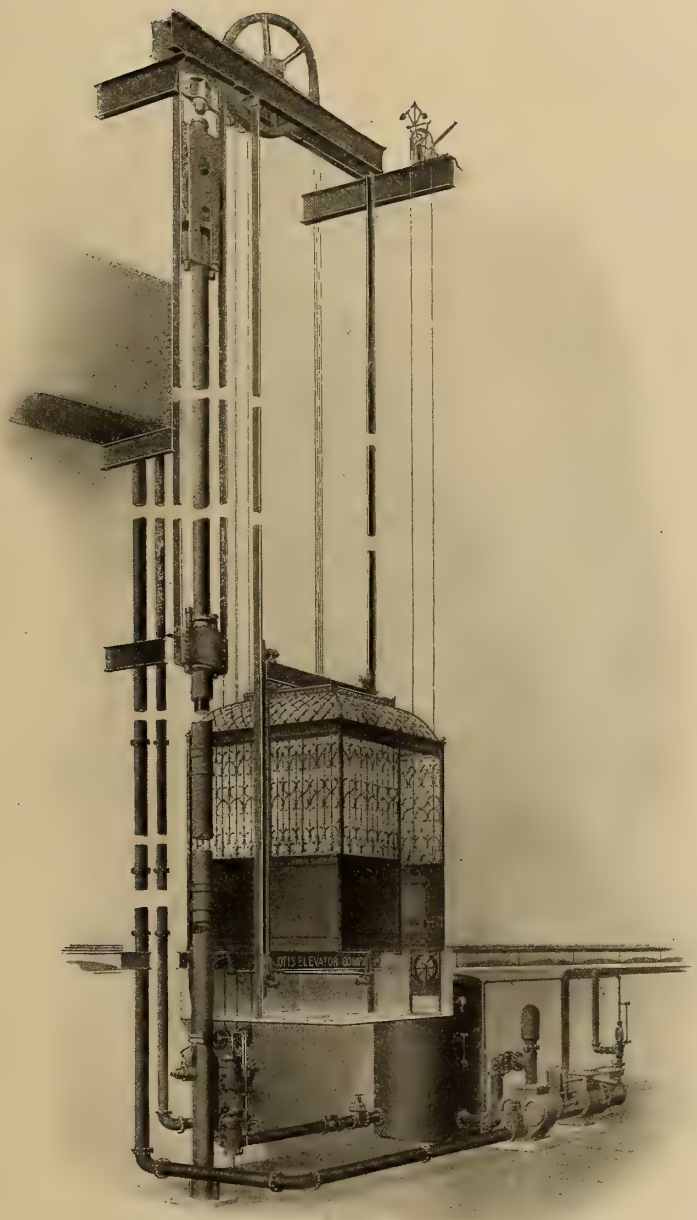
The success of the two buildings mentioned led to the erection of many others in lower New York, and the demand for passenger elevators grew enormously there and in the enterprising West.

Real estate values rose with the height of the buildings, and the elevator became a most important factor in the development of great cities. Safety and certainty of control were the two elements demanding most attention, and to Cyrus W. Baldwin, of the Hale Elevator Company, of Chicago, belongs the credit of having effected the first practical solution of the problems presented. He invented, and subsequently, under the direction of Otis Brothers, perfected the vertical cylinder hydraulic elevator. Contemporaneously Charles Whittier developed the horizontal cylinder hydraulic elevator, and competition also sprang up in Chicago by the interests of Richard T. Crane.

The passenger elevator had come to stay, and the height of new buildings was limited only by the possibilities, or limitations, of the elevator equipment. With the increase in height of buildings, and the keen

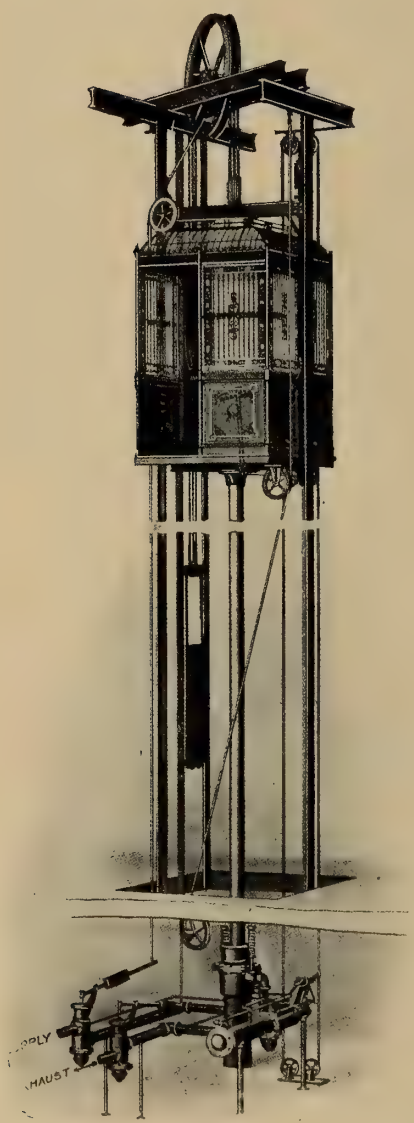


STANDARD VERTICAL CYLINDER HYDRAULIC ELEVATOR

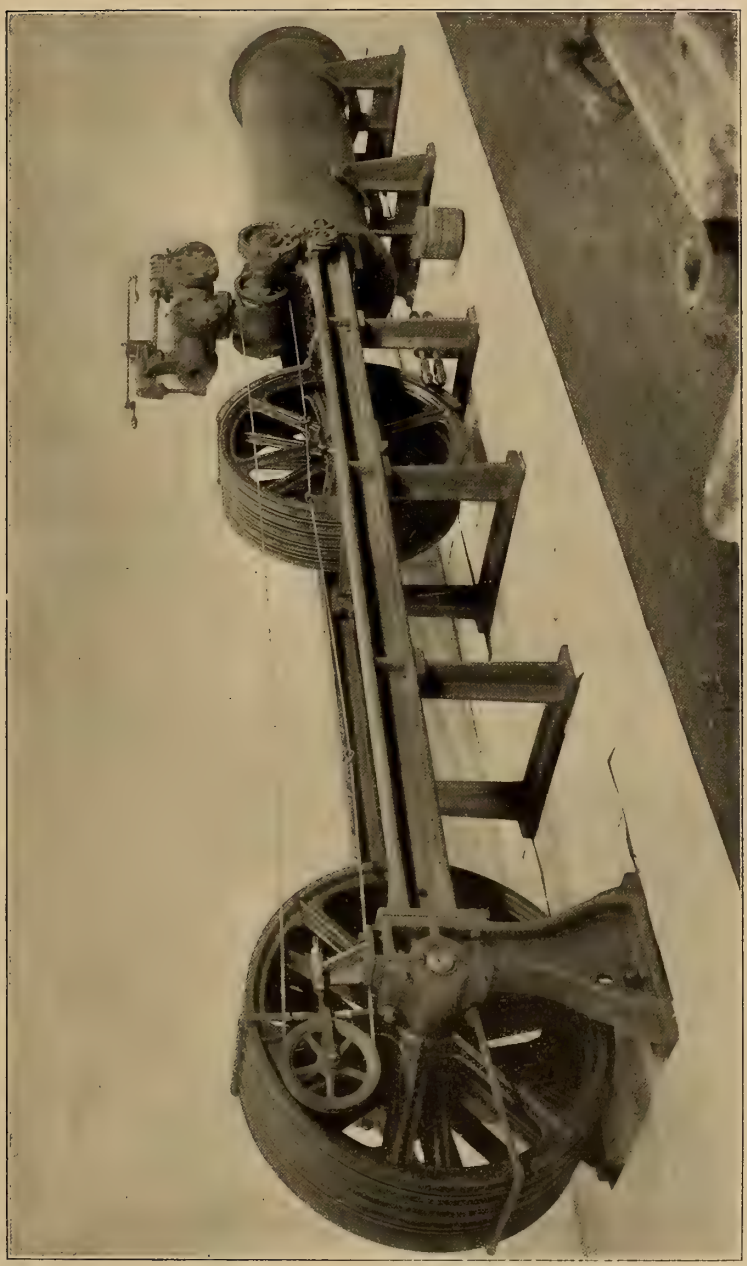


PULLING PLUNGER ELEVATOR

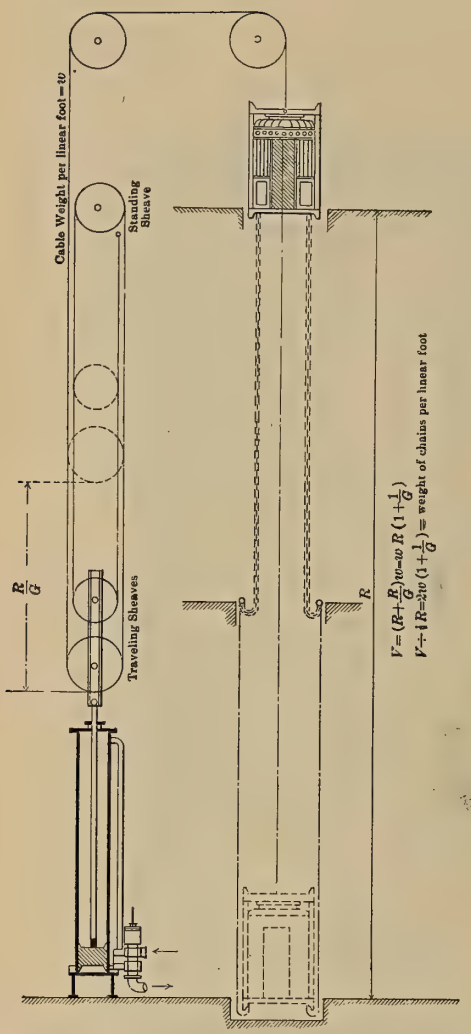
competition for tenants, it was quite natural that the demands of architects, builders and owners for increased speed in elevators became more and more exacting, until the limits of prudence and safety had been passed, and the ingenuity of the elevator builder was sorely taxed to keep pace with these demands. While a speed of 200 feet per minute for a building 8 or 10 stories in height was considered quite adequate, yet when the height of buildings, owing to the introduction of steel skeleton construction, was carried up to 20 stories or more, a speed of 500 to 600 feet per minute was demanded. With the general adoption of the steel construction, there came also a revolution in the elevator industry, as was first pointed out by Mr. Thomas E. Brown, Jr., in his paper on "Passenger Elevators," read before the International Engineering Congress in St. Louis in 1904, for now no longer did the elevator builder control the situation and limit the height of buildings, but the architect, engineer and builder carried their structures up as high as foundations and steel structures would permit, and demanded elevators which would confirm to these conditions. Simultaneously high-pressure hydraulic elevators, designed to occupy a minimum of space, and multiple sheave electric elevators of the Sprague-Pratt type were offered to meet the demand of the times. The Sprague elevator, while unique and ingenious in design and construction, involved faulty mechanical principles, resulting in extravagant power-consumption and heavy cost for maintenance and repair, so that after a meteoric but rather brief career, it disappeared from the market, and many costly installations of this type have been replaced with hydraulic or other forms of machines. The drum type of electric elevator, first offered by the Otis Company in 1889, found much favour in New York, where electric power was available from mains laid for illuminating purposes in the principal streets, and owing to the greatly reduced cost of operation, this made it possible to install elevators in small and comparatively low buildings. The logical effect of the great increase in the number of elevators installed was a wonderful enhancement in real-estate values, and an extension of building operations into remoter sections, where building could now be carried



MODERN PLUNGER ELEVATOR



LOW-PRESSURE HORIZONTAL HYDRAULIC-ELEVATOR ENGINE

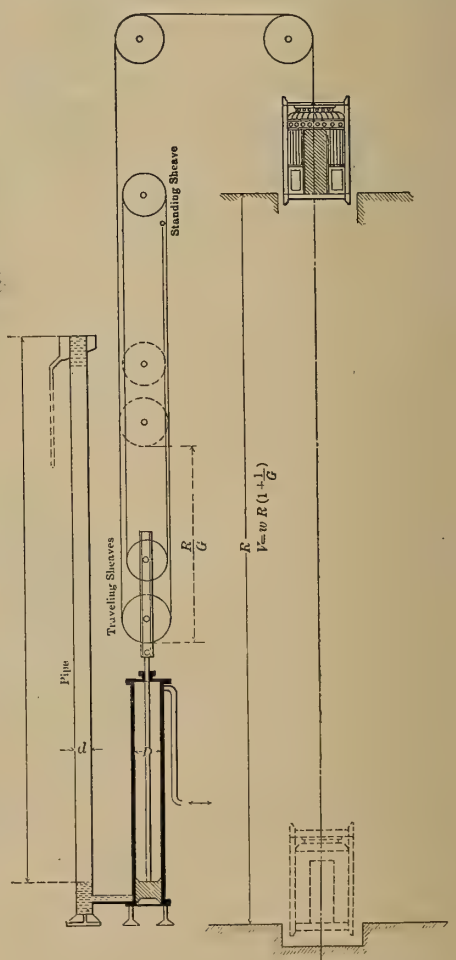

Cable Weight per linear foot = w
Standing Sheave
Traveling Sheaves
R/G
R
V = (R + R/G) w = w R (1 + 1/G)
V = 1 R = 2w (1 + 1/G) = weight of chains per linear foot

HYDRAULIC ELEVATOR WITH CHAIN COMPENSATION FOR ROPE VARIATION

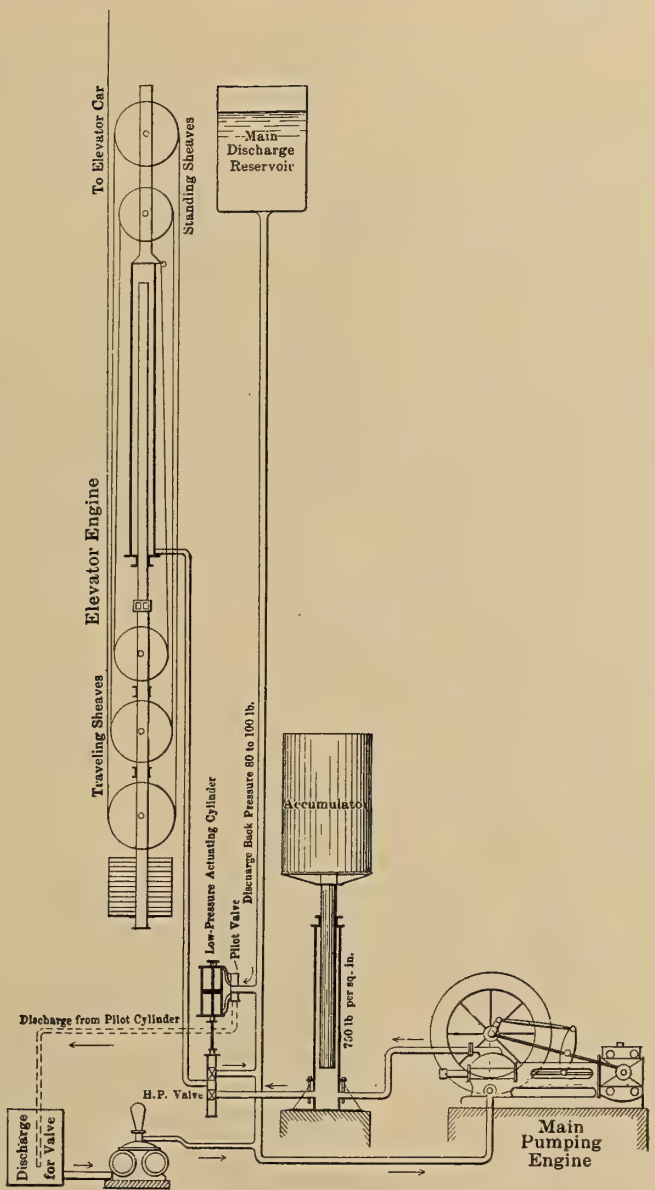
up to heights making a profitable investment of apartment dwellings, which would have been impossible before the perfection of the elevator rendered the upper stories more desirable than the lower.

In the early 90's there sprang up a demand for elevators designed especially for residences, with an operating and controlling system so simplified as to be safely placed in the hands of women, children and servants. Such elevators, rather crude in form and exceedingly slow in speed, had been in use in Paris for some years, and American inventive genius proceeded to perfect the system until now there are more than 600 such elevators in use in residences in New York, and many others in large cities in the United States and in Europe, and in New York the plans of any residence costing $50,000 or more, either include a passenger elevator or a provision for installing one if desired.

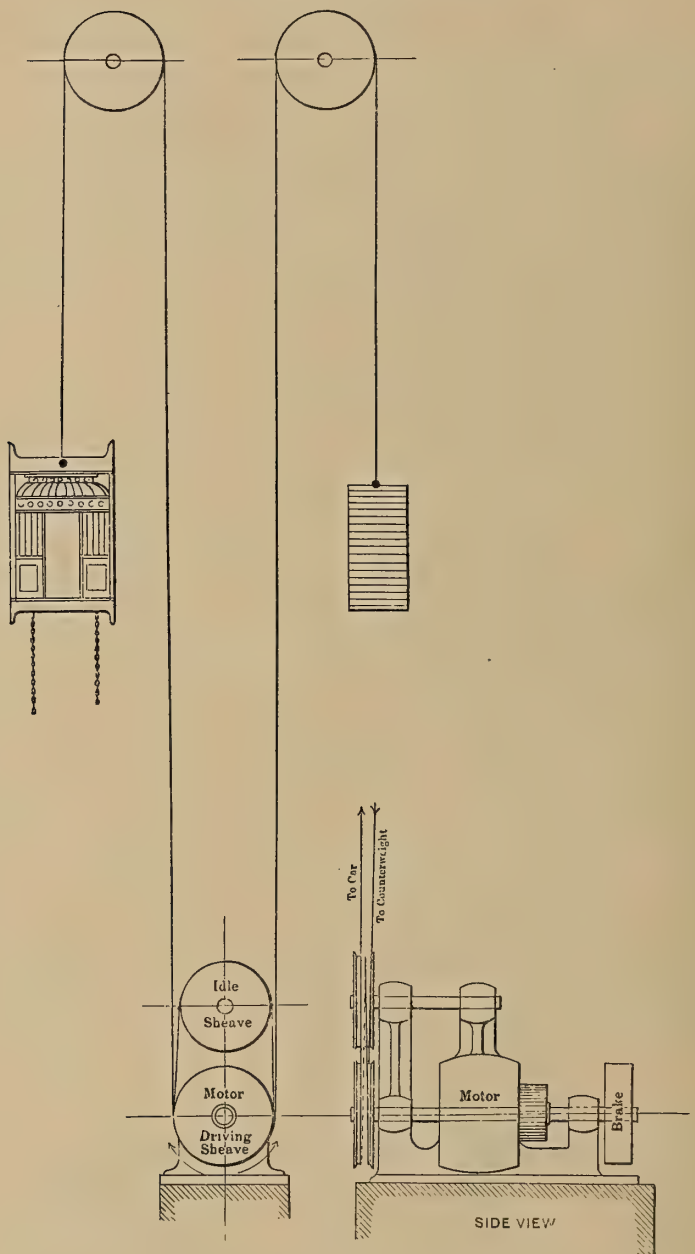
The interlocking devices between the elevator enclosure doors and the car controller render an accident almost impossible, and as the car is automatically controlled by push buttons in hall and car, the elevator may



HYDRAULIC ELEVATOR WITH WATER-COLUMN COMPENSATION



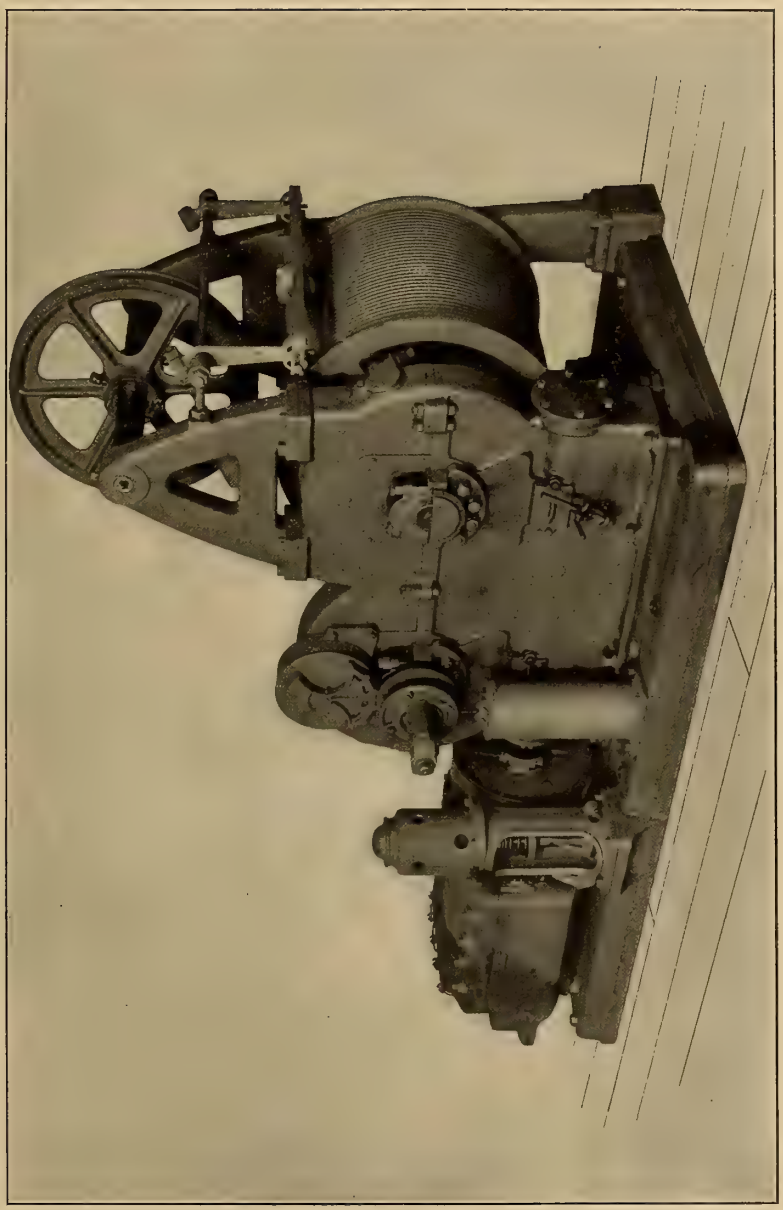
HIGH PRESSURE HYDRAULIC ELEVATOR WITH LOW-PRESSURE PILOT VALVE OPERATED BY DISCHARGE BACK PRESSURE



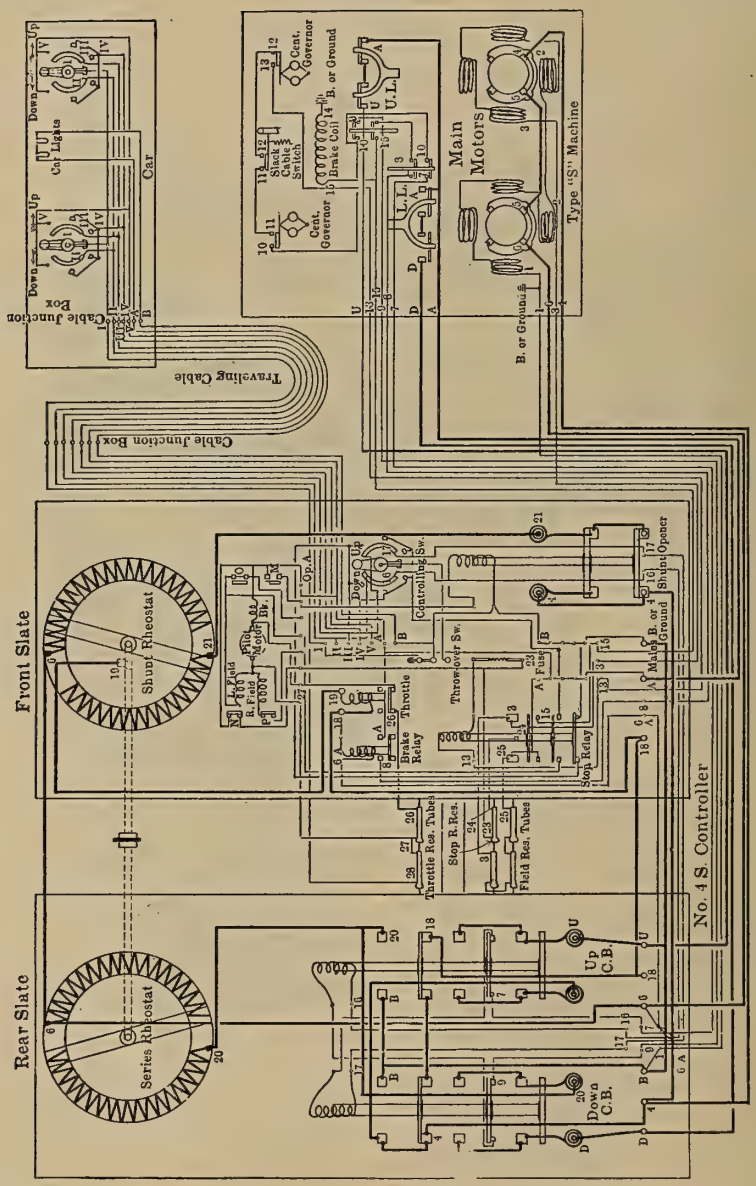
ELECTRIC ELEVATOR WITH CABLE DRIVE

be operated with safety by a child. There are a number of residences in New York containing three or more such elevators.

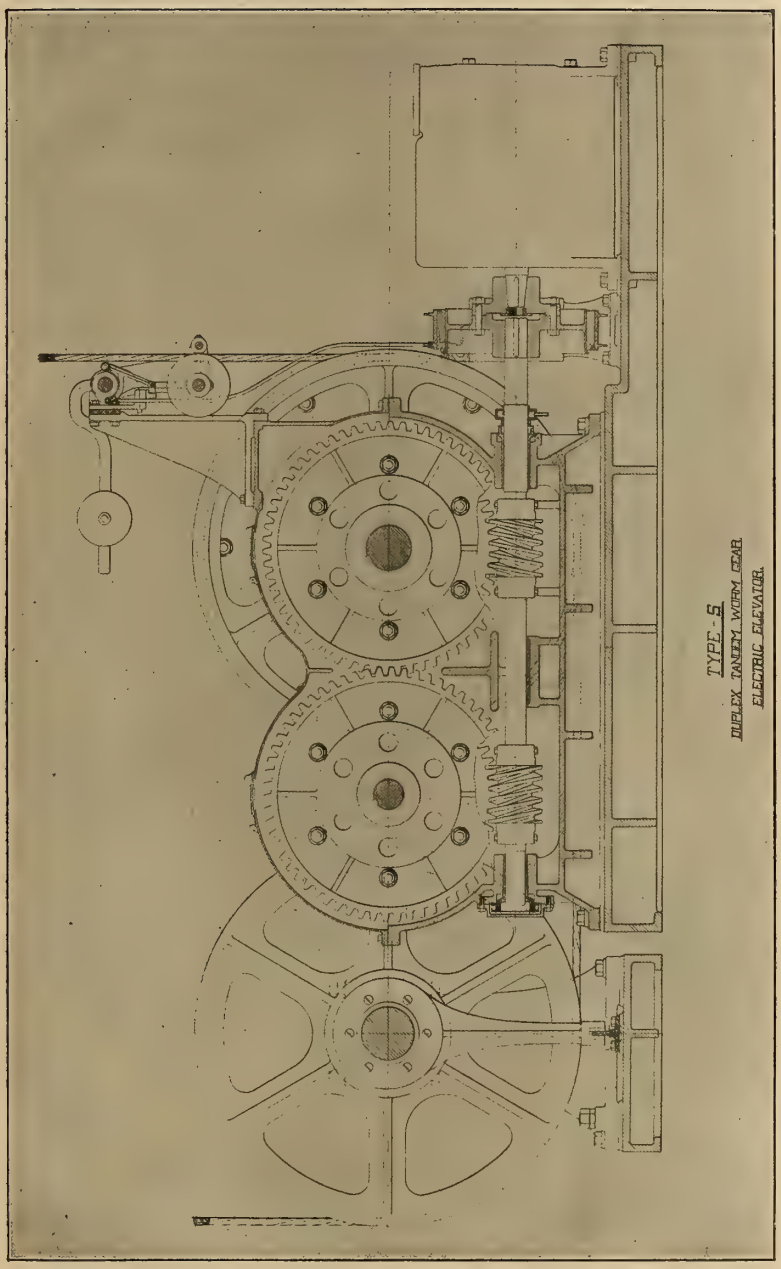
The extensive use of the plunger elevator for passenger purposes was first made possible by the inventions and improvements perfected by Prof. George I. Alden, of the Worcester Polytechnic Institute, and his associates. This type of elevator had previously been used for many years



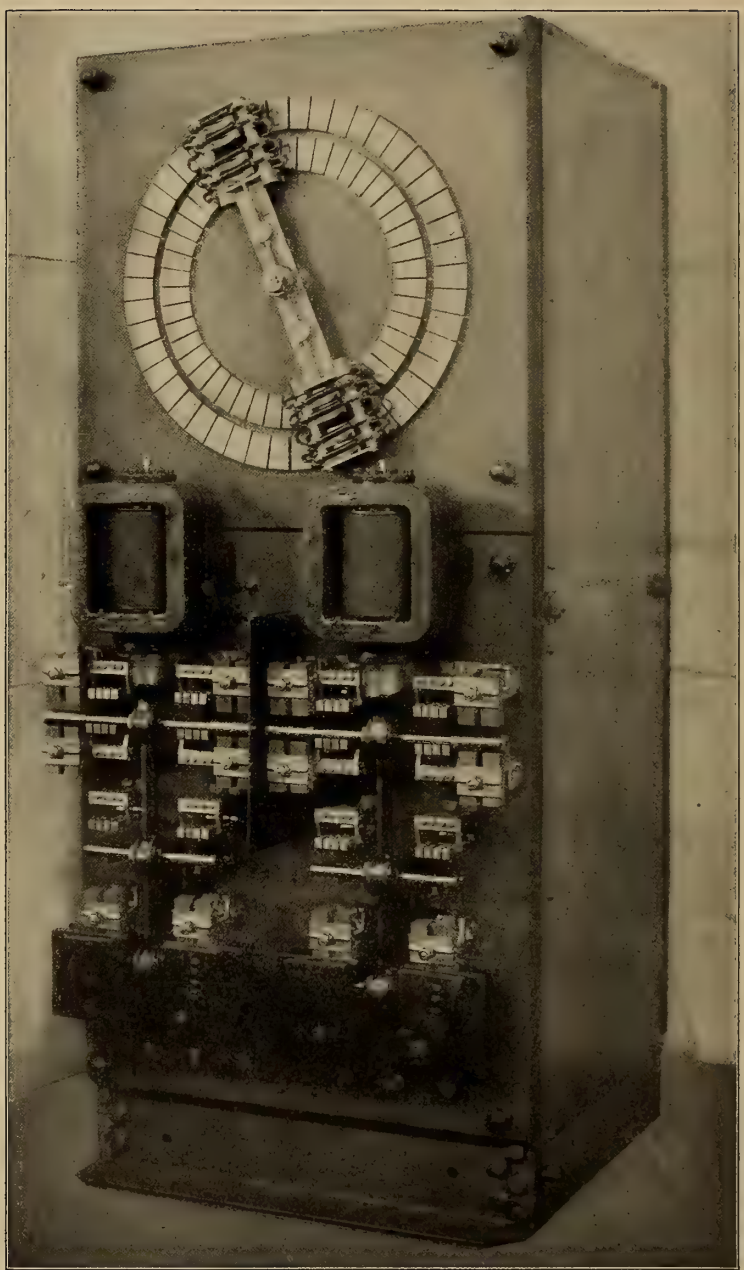
ELECTRIC ELEVATOR ENGINE, DRUM TYPE



WIRING DIAGRAM OF CONTROL OF SPRAGUE ELECTRIC ELEVATOR. LONDON CENTRAL RAILWAY



MECHANISM OF SPRAGUE ELECTRIC ELEVATOR. LONDON CENTRAL RAILWAY



SPRAGUE CONTROLLER. LONDON CENTRAL RAILWAY

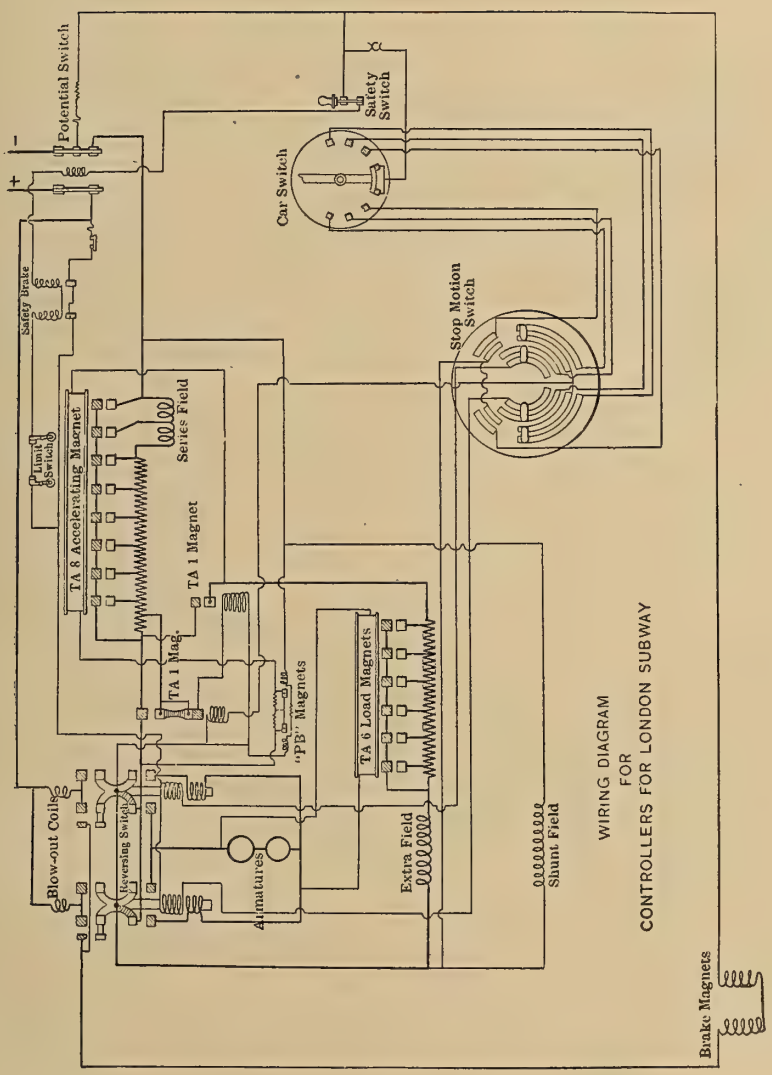
to a considerable extent for freight purposes where high speed was not required, but only to a very limited extent for passenger purposes, because of difficulties experienced in controlling the car at high speed, and because of the wastefulness of the system under the old methods of construction with an invariable counterbalance. With a well-designed and constructed 3-way balanced piston valve and a water-balance effected by discharging into an elevated tank with a variable counterbalance compensating for the increase and decrease in weight of plunger as it rises and falls, the plunger elevator became very popular for passenger service, and the business of manufacturing and installing it grew to such proportion that two large modern shops were devoted exclusively to its manufacture. That this type of elevator has its limitations was admitted by its warmest advocates, and although theoretically very safe because of the steel column always under the car, yet it is acknowledged that this consideration has little weight in elevators of this type when carried to such heights as 300 to 400 feet, as is the case in a number of existing equipments. It is also true that one of the worst elevator accidents on record occurred to an elevator of this type in the Grand Hotel in Paris.

The year 1906 witnessed another complete revolution in the elevator industry, for while up to that time there had been a gradual tendency to keep down the height of office buildings, suddenly plans were presented requiring elevators to travel to a height of 41 stories for one structure and 45 stories for another, both located in New York.

These conditions exceeded the economic possibilities of the hydraulic and electric types of elevators then in use. The hydraulic type would consume too much space, and the drum-driven electric type was impractical because of the great size of drum required and difficulties of control and the high speed demanded. To meet these conditions, an improved type of electric elevator, involving the cable-drive or direct traction principle formerly used in driving cable-cars was devised, and is to be installed in a building in lower Broadway, having a travel of 41 stories, a total rise of 525 feet. While this type of elevator is strictly not experimental, several having been in operation in New York and Chicago for about two years, yet its performance under the trying conditions imposed by the building in question will be noted with much interest by engineers.

The tendency to increase the speed of passenger elevators to satisfy the demand of an eager and restless public, and of grasping and reckless owners, has happily received a wholesome check in most of the large cities of America by wise restrictive legislation, limiting the maximum speed of elevators to a rate within reason, and to some extent proportioned to the character of the service. The effect of such legislation upon real estate values and building operations was most wholesome, for numerous accidents, caused by elevators running at a rate beyond the limits of safety, had begun to create a feeling of general distrust which threatened the elevator industry, as well as real estate operations. The main cause of the trouble lay in the fact that in order to economize in the cost of buildings, a tendency to provide for an insufficient number of elevators in a building had grown up, thus taxing the cars beyond their safe capacity. Experience has demonstrated that there is a definite and fixed relation between the rentable floor space in an office building and the number of elevators required, their ratio being, in the most active buildings, 25,000 square feet of rentable space per elevator, and when this ratio is much exceeded, the elevator service is inadequate. Cars of moderate size have been found more efficient, because of the total time re-

MAGNET CONTROLLER FOR DRUM TYPE ELECTRIC ELEVATOR



WIRING DIAGRAM FOR ELECTRIC ELEVATOR, DOUBLE-DRUM TYPE

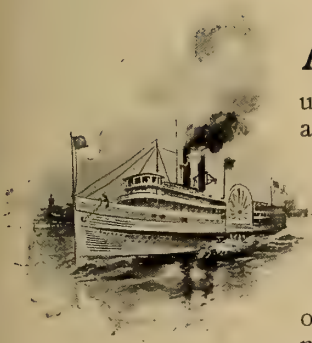
quired for a round trip; 75 per cent. is consumed by ingress and egress of passengers, thus practically nullifying with large cars any possible advantage by running at high speed between floors.

The American elevator has been most favourably received in other countries, and a very large business has resulted. Beginning with the large and complex equipment of the Eiffel Tower, confidence in the safety of American elevators was established, and the business grew until now it amounts to millions of dollars annually. One contract is now being executed for 170 elevators for the London Underground railway system, each of which has a carrying capacity of fifty persons.

The growth of this industry in the United States in the last twenty years has been remarkable, the total sales having increased from about two and one-half millions of dollars in 1886, to more than thirty millions in 1906, and the number of elevators in operation in New York City alone, from about four thousand to about eighteen thousand. Of these, eighteen thousand elevators, about fifteen thousand are passenger elevators, carrying daily not fewer than two millions of passengers.

FULTON IN FRANCE

By Henry Harrison Suplee



AT the present time, when plans are under discussion for a proper commemoration of the one-hundredth anniversary of the successful inauguration of commercial steam navigation by Fulton upon the waters of the Hudson, it is interesting to consider some of the earlier efforts which he made to develop the steamboat in Europe.

It is now generally accepted that the part which Fulton bore in the application of steam power to the propulsion of vessels was that of development rather than of original invention, but at the same time he brought to this work such a knowledge as enabled him to produce a complete working steamboat, and not a mere experimental machine, and the *Clermont*, from the time of her first trip to Albany in 1807, continued in regular service on the river, followed closely by the *Car of Neptune* and the *Paragon*, built practically upon the same lines and proportions.

It is not intended here to discuss the development of steam navigation in general, but rather to examine an earlier period in the life of Fulton, a period in which the efforts of the American civilian came very near turning the whole course of European history into channels altogether different from those which it actually followed.

Robert Fulton, who was born in 1765, went to England in 1787, his original intention being, apparently, to devote himself to the study of portraiture under his fellow-countryman, Benjamin West. As he did not return to America until 1806, and died in 1815, by far the greater part of his adult years was spent in Europe, and it was during his life in France especially that he really developed the plans which it was destined he should exploit successfully in his native country.

During his earlier years in England, while not neglecting his studies in art, he undoubtedly gave much attention to engineering subjects, and especially to improvements in internal waterways. His talent for mechanics was such that the young American soon made the acquaintance of such men as the Duke of Bridgewater, Earl Stanhope, and James Watt. His plans for inclined planes as a substitute for canal locks were patented in England in 1794, but do not seem to have met with any practical application at that time.

In 1797, almost immediately after the restoration of order in France after the revolution, Fulton decided to go to Paris, and there endeavour to introduce his improvements in internal navigation. Doubtless the atmosphere of military excitement with which he found himself there surrounded, caused him to divert his attention to inventions relating to warfare, and we find him soon in the midst of plans for the development of fighting machinery.

In order to realize fully the opportunity which this period offered to such a man as Fulton, filled with ideas for revolutionizing methods of

warfare, and endowed with a persistence and continuity of effort which gave added impetus to his ideas, it is desirable to take a brief survey of the political situation at the close of the eighteenth and the beginning of the nineteenth century.

Since February, 1793, England had been at war with France, and, indeed, France was at war with all the rest of Europe. Since 1795 Napoleon had been at the head of the army, and in 1797, when Fulton first arrived in Paris and went to the house of his fellow-countryman, Joel Barlow, Napoleon was in the midst of his early brilliant Italian campaign, and the Directory, with Lareveillere, Rewbell, Letourneur, Barras and Carnot at the head, was in the saddle.

Napoleon's successes in the campaign against the Austrians had effectually removed any anxiety in Paris so far as land warfare was concerned. England's share in the contest, apart from furnishing funds, was at this time limited to the command of the sea, and the victories of Cape St. Vincent and of Camperdown had demonstrated that it was upon the water and in naval warfare that France was deficient.

Although Fulton was received with open arms by Mr. Barlow upon his arrival in Paris, it was evident that the first thing to be done was to arrange for some means of livelihood. Portrait painting offered little or no opportunity in such disturbed times, and something more popular was necessary, something which should appeal to the gay crowds, which, heedless of the terrible scenes with which the past few years had been filled, were ready and seeking for any novelty.

Doubtless the practical business judgment of Mr. Barlow had much to do with the matter, and the result was the painting by Fulton of a panorama, which, after being set up in a convenient location, became very popular, and provided Fulton with an entirely sufficient means of support. The visitor to Paris to-day passes through the *Rue des Panoramas* and the *Passage des Panoramas* without realizing that these names tell him they are remains of the first efforts of Robert Fulton to support himself in Paris while he was developing his plans for overcoming the naval power of England by means of torpedoes and steamboats.

During Fulton's residence with Mr. Barlow he not only managed his panorama, but acquired the French language, together with some knowledge of German and Italian, and studied higher mathematics, physics and chemistry, thus adding a sound theoretical training to the natural taste for mechanics which he already possessed.

Almost immediately after Fulton had thus succeeded in establishing himself in Paris, he began experimenting with submarine explosives, but these early attempts, confined to himself and Barlow, were unsuccessful, except in so far as they furnished data for subsequent efforts.

As, when in England, Fulton had become acquainted with men of such scientific eminence as Watt, the Duke of Bridgewater, and Earl Stanhope, so in France he soon formed the acquaintance of the ablest member of the original Directory, Carnot, subsequently the Minister of War of Napoleon, the "Organizer of Victory." Carnot had already prepared his plan for the invasion of England, and had he remained in power it is altogether possible that the various propositions which Fulton made to the government might have been given a more favourable reception, but the revolution of the 18 Fructidor (September 3, 1797), deprived Carnot of power, and Fulton's immediate access to the government was ended.

In the meantime the war went on. Napoleon was absent in Egypt, where the Battle of the Nile again demonstrated to France how weak she was upon the water, in spite of her ever-increasing strength on land. Then came the return of Napoleon from

Egypt, followed by the revolution of the 18th Brumaire (November 9, 1799), the overthrow of the Directory, and the formation of the Consulate, with Napoleon at the head of the government.

The campaign of Marengo brought peace with Austria, but England and France still remained at war. Meanwhile Fulton had not been idle, but had been studying, not only to improve his torpedoes, but also to render submarine navigation a possibility. He was already familiar with the work of Bushnell, in America, and believed that it required only the application of correct mechanical design to the principles which Bushnell had enunciated, to make a practical submarine which should render the existing British navy obsolete.

Something surely was necessary if British power was to be overcome. All Napoleon's victories in Italy, Egypt and Austria were of no avail if the victorious British fleets were to continue to sweep the seas. French commerce was annihilated, French fisheries were ruined, French ports declared to be in a state of blockade, and the united fleets of Russia, Sweden and Denmark, gathered to raise the blockade, were shattered at Copenhagen.

Then came the first assemblage of troops and transports at Boulogne to threaten an attack on the coast of England, and in the summer of 1801 the Channel was the scene of continual skirmishes between French gunboats and divisions of the British fleet.

Under such circumstances the active mind of Fulton realized that something more than torpedoes and hand-operated submarines was demanded. Although he had as yet not reached the experimental stage in his plans for steam navigation, he felt so sure of ultimate success that he made a formal offer to the French government to place in its hands a new weapon.

Already it was realized in France that the only chance for an attack upon England was to be gained by an opportunity to slip across the Channel during the absence of the watchful Nelson. Riouffe, an orator of the day, had well expressed the prevailing opinion when he said that what they most needed was "a fair breeze and thirty-six hours."

ROBERT FULTON, FROM THE BRONZE ON THE MONUMENT IN TRINITY CHURCHYARD IN NEW YORK

Fulton had something still better to offer. Writing directly to the First Consul, he said:

"The sea which separates you from your enemy gives him an immense advantage over you. Aided in turn by the winds and the tempests, he defies you from his inaccessible island. I have it in my power to cause this obstacle which protects him to disappear. In spite of all his fleets, and in any weather, I can transport your armies to his territory in a few hours, without fear of the tempests and without depending upon the winds. I am prepared to submit my plans."

Napoleon was evidently impressed by Fulton's earnestness, for he referred the matter to a commission, consisting of Volney, La Place, and Monge. Of the competency of such a board no question can be admitted, but, like every body of eminent scientists, they had great reputations to lose, and they were as conservative as such a body might well have been expected to be.

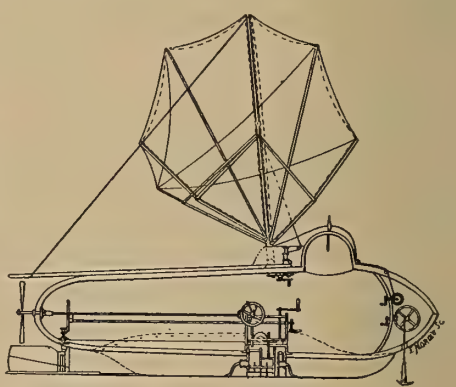
Bignon, the French historian, says of this commission, and the proposition which Fulton laid before them:

"A great truth, a plain physical fact was before their eyes; but they did not perceive it, they utterly failed to grasp it. Was it due to their prejudices, or to their negligence, that they permitted it to escape them? It is impossible to tell this to-day, but Fulton was repulsed by them as a visionary.*

"Suppose the existence of a single operative steamboat in 1801! Instantly we can see every forge, every workshop, every foundry in France, from Marseilles to the north of Holland, busily engaged in multiplying the original. In a few years there would have been a hundred, two hundred such steamboats, ready to tow behind them thousands of transports laden with troops ready, like their leader, for the boldest of enterprises.

"The men and the times were ripe alike for just such a novelty. The discovery seemed made especially for this period. A half-century, perhaps a century, will now be necessary to complete a maritime revolution, for which five or ten years would have sufficed for Bonaparte, Consul or Emperor. How can it be doubted that at the sight of such a tremendous power in his hands, and the realization of the approach of such a danger, England would have been forced to submit to a peace, and admit the reality of the power of France. Thus may the fate of nations depend upon a new idea; thus Nature conceals within her bosom many unknown forces, of which a single one is sufficient to change the destinies of the world."

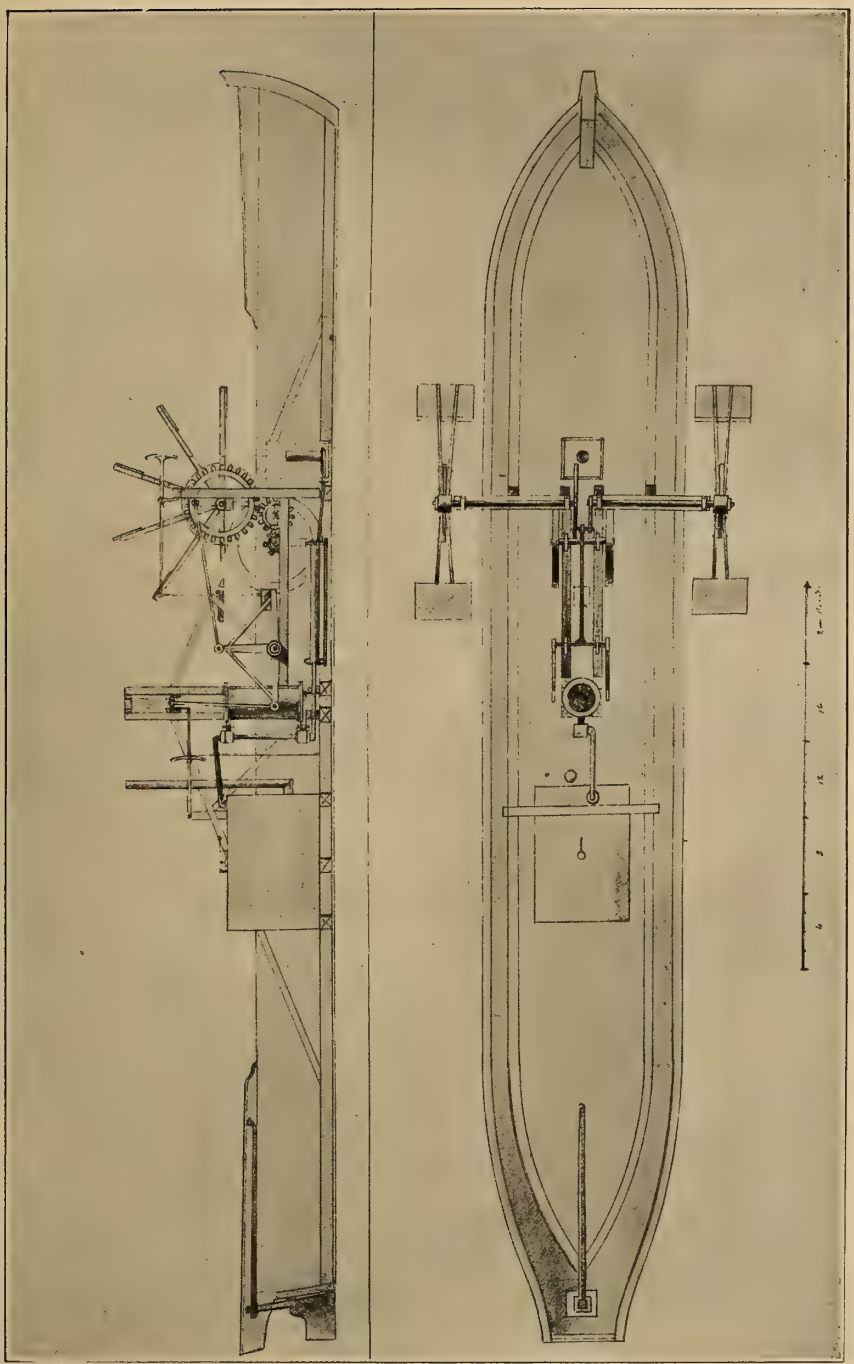
Fulton's plans were not rejected without a trial, however, at least so far as the torpedo and the submarine were concerned; the steamboat was to come later. During this very summer of 1801, in the harbour of Brest, where France has just been receiving visits from the great steam navies of the world, Fulton made successful experiments with his plunging boat. Napoleon had allowed an expenditure of 10,000 francs, and a boat of cigar shape, 2 meters in diameter, and 6.50 meters long, was ready in May, 1801. This boat was constructed of iron and copper, and was propelled by a screw operated by manual effort. The submersion was effected by the admission of water, while the pumping out of the water caused the boat to rise again. A collapsible sail and rigging enabled the boat to proceed under wind when not submerged. With this boat, named the *Nautilus,* Fulton, accompanied by one sailor, descended in the Seine and remained below for twenty minutes, rising to the surface at will, and seeming to have the boat under perfect control. At Brest, in June, 1801, with three companions, he descended to a depth of 25 feet, remaining below for an hour, and manœuvring the boat in various directions; and with the aid of a reservoir of compressed air, of one foot cubic capacity, at a pressure of 200 atmospheres, he succeeded in remaining beneath the surface for nearly five hours.



THE NAUTILUS, FULTON'S SUBMARINE TESTED AT BREST IN 1801

The *Nautilus* had a submerged speed, with manual power, of about

*Some of the members of this commission are yet living (1829). They say in excuse of their action, that the proposition of Fulton was accompanied with a number of foolish ideas which prevented them from grasping the fundamental truths, concealed under a mass of errors. Put not your trust in scientists. (Bignon).



FULTON'S DRAWING FOR A STEAMBOAT, SUBMITTED TO THE COMMISSION APPOINTED BY NAPOLEON IN 1803. FROM THE ORIGINAL DRAWING IN THE CONSERVATOIRE DES ARTS ET METIERS, PARIS

one mile per hour. At the request of the commissioners, he made an attack upon a small boat placed at his service, and succeeded in attaching to it, by means of the *Nautilus,* a torpedo containing twenty pounds of powder, which, being exploded, blew the hull to fragments. This was in August, 1801.

There appears to have been no doubt as to the complete fulfillment of all his promises concerning the submarine, and yet the report was unfavourable.

In the face of such successful performances, how came the Commission to reject Fulton's plans?

Fulton's moderate demands for his services and his inventions were as follows: The cost of the *Nautilus,* some 40,000 francs, was to be reimbursed to him, this sum including 10,000 francs advanced by the government. For each vessel destroyed by him he was to receive prize money, and, finally, he demanded an official recognition of himself and his men as belligerents, in order that they might not be hung as pirates, if by any chance they should be captured.

Curiously enough, it was upon this last demand that the difficulty arose. Admiral Pleville-le-Pelley, the Minister of Marine of the government, as well as Caffarelli, the Maritime Prefect at Brest, maintained that it was impossible to consider giving commissions to men who used such methods against the enemy. Fulton's request to be allowed to make an attack upon a British frigate was refused, with the statement that any one employing such appliances would certainly be hung should he fall into the hands of the enemy.

The feint of Napoleon against England having passed, and peace negotiations having resulted in the conclusion of the Treaty of Amiens, in March, 1802, Fulton turned his attention from the torpedo and the submarine to his long meditated plans for a steamboat.

By the beginning of 1803 he was ready to construct a boat, and again having applied to the government, he was referred to a new commission, consisting of Citizens Molard, Bandell and Montgolfier, the latter being the well-known inventor of the hot-air balloon. Fortunately the communication which Fulton made to this commission has been preserved in the archives of Conservatoire des Arts et Métiers, in Paris, including the drawing which Fulton submitted of his proposed steamboat, and these invaluable records of the efforts of Fulton in France are here reproduced. It will be noted that Fulton carefully abstains from mentioning the obvious applicability of the steamboat for purposes of military transport; peace had now come, and it was to peaceful pursuits that he recommended his invention.

LETTER OF FULTON TO THE FRENCH COMMISSION.

(See pages 409, 412, 413.)

[Translation.]

PARIS, 4 Pluviose, Year XI.
(25 January, 1803).

Robert Fulton to Citizens Molar, Bandell and Montgolfier.

Friends of the Arts.—I send you herewith sketch designs of a machine which I am about to construct with which I propose soon to make experiments upon the towing of boats upon rivers by the aid of fire engines. My original object in attempting this was to put it in practice upon the great rivers of America where there are no roads suitable for hauling nor indeed are any hardly practicable, and where, in consequence the cost of navigation by the aid of steam would be put in comparison with the labour of men and not with that of horses as in France.

You can see that such a discovery, if successful, would be infinitely more important in America than in France where there exists everywhere roads suitable for hauling, and companies established for the transport of merchandise at such moderate charges that I doubt very much if a steam boat, however perfect it might be, could be able to gain anything over horses for merchandise. But for passengers it is possible to gain something because of the speed.

In these plans you will find nothing new, since this is not the case with paddle wheels, an appliance which has often been tried and always abandoned because it was believed that it had a disadvantageous action in the water. But, after the experiments which I have made already I am convinced that the fault is not in the wheel,

but in the ignorance concerning its proportions, its speed, the power required, and probably in the mechanical combination.

I have proved by very accurate experiment that paddle wheels are much to be preferred to bands of paddles, and in consequence, although the wheels are not a new application, yet nevertheless I have combined them in such a manner that a large portion of the power of the engine acts to propel the boat in the same way as if they rolled upon the ground; the combination is infinitely better than anything which has as yet been done up to the present time, and it is in fact a new discovery.

For the transport of merchandise I propose to use a boat with an engine arranged to draw one or several loaded barges, each one so close to the preceding one that the water cannot flow between to make resistance. I have already done this in my patent for small channels, and this is indispensable for boats moved by fire engines.

EXAMPLE:

SKETCH IN FULTON'S LETTER

Suppose the boat A, with the engine, presents to the water a face of 20 feet, but inclined at an angle of 50 degrees, it will be necessary to have a machine of 420 pounds power making 3 feet per second to move one league per hour in still water. If the boats B and C have their faces parallel to that of A they will each also require a force of 420 pounds, that is to say 1200 pounds for the three, while if they are connected in the manner in which I have indicated, the force of 420 will suffice for all, and this great economy of power is too important to be neglected in such an undertaking.

CITIZENS:

When my experiments are ready I shall have the pleasure to invite you to see them, and if they are successful I reserve the privilege of presenting my labours to the republic or of taking for them such advantages as the law may authorize. At the present time I place these notes in your hands in order that if any similar project comes before you before my experiments are completed, they shall not have the preference over mine.

With respectful salutations,

ROBERT FULTON.

No. 50 Rue Vaugirard.

An examination of the drawings of the engine in these plans will show many original features. The bell-crank beam is well adapted to the relative positions of the cylinder and paddle wheels, and permits a long stroke to be obtained while at the same time keeping the centre of gravity low. The geared fly-wheel is also original, and enables an effective speed regulation to be secured with a small wheel. Although the engine was to be built by Boulton and Watt, it was entirely different from their usual designs, and must be considered as original in plan with Fulton himself.

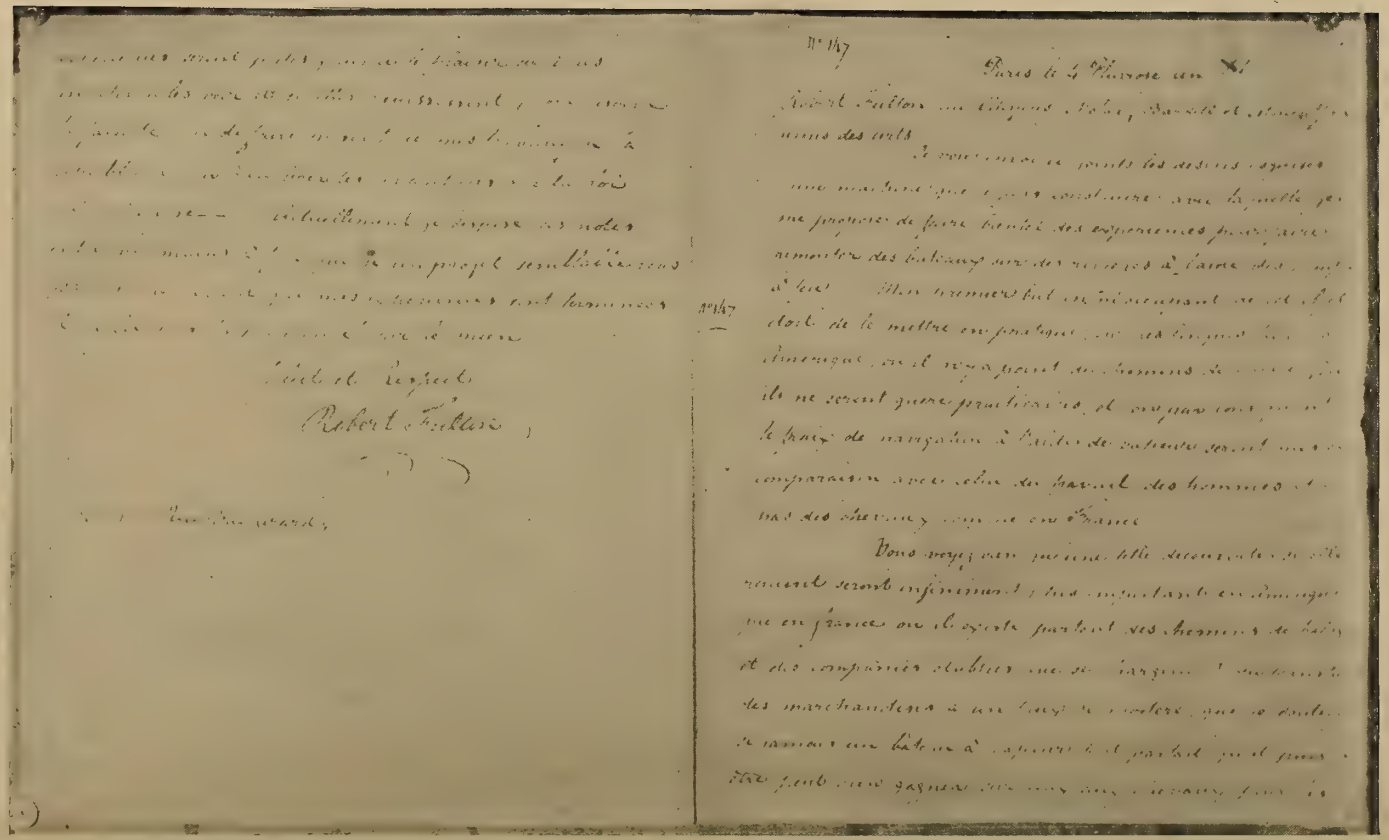
This plan was submitted in January, 1803, and early in the spring Fulton had a small boat fitted with boiler, engine and paddle wheels, ready for an exhibition trial before the Commission. Unfortunately, just as Fulton was prepared to make the exhibition which was to decide the fate of steam navigation in France, a deplorable accident occurred. During the night a heavy wind had caused the Seine to be violently agitated, and the weight of the heavy machinery being too great for the strength of the little boat, it had broken through the hull and the whole affair had gone to the bottom.

The best account of this critical disaster is given by Dr. Edward Everett Hale, the venerable chaplain of the United States Senate, as he had it told him by Edward Church, who was with Fulton in Paris at the time.

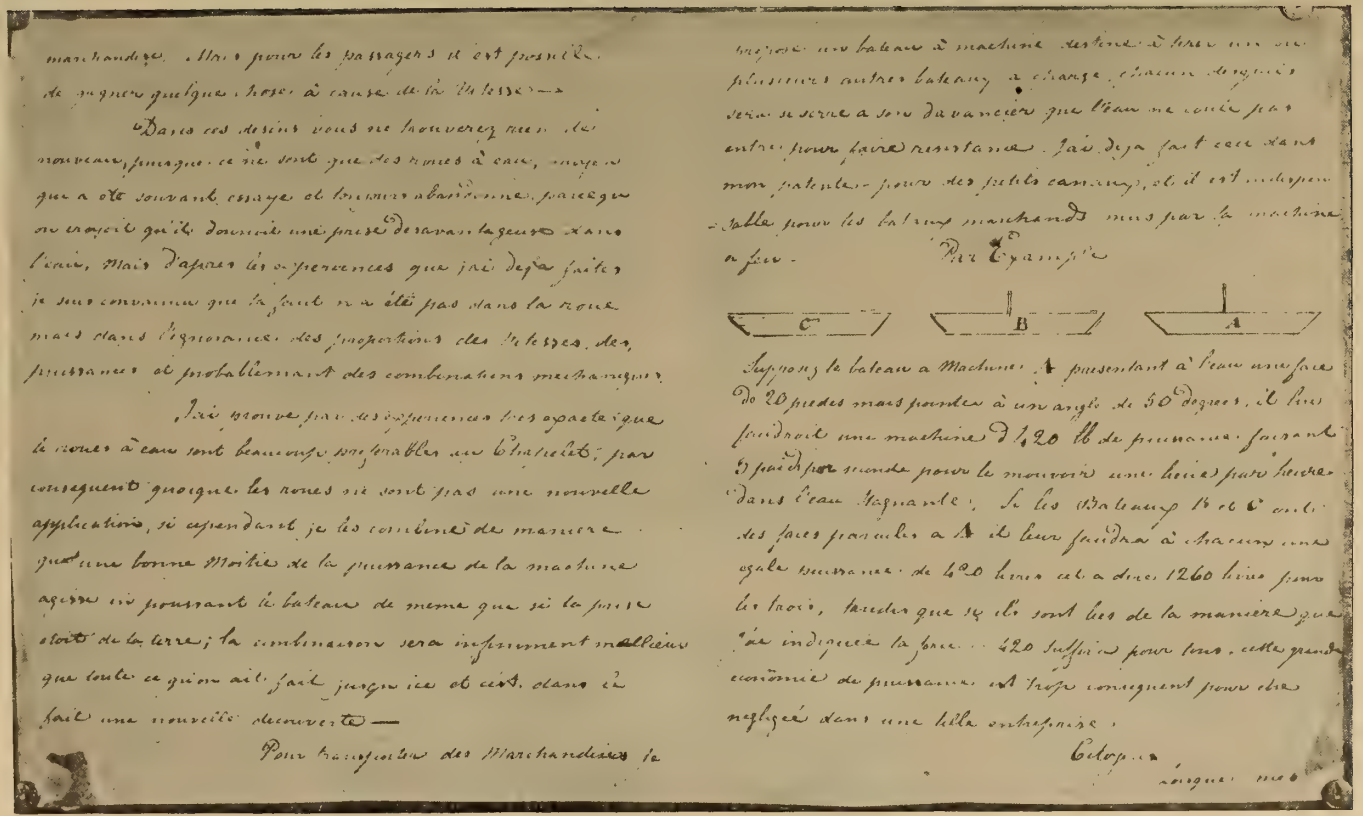
Dr. Hale says:

"It was in the spring of 1843 that I met Edward Church. He was then an old gentleman living in Northampton, Massachusetts, highly respected. He had been the intimate friend of Fulton, and after the success of the *Clermont* here he was acting under Fulton's inspiration in introducing steam navigation on the lakes and the rivers of the continent.

"He was in Fulton's bedroom, when, early in the morning of the fatal day, a messenger at the door announced the sinking of the little vessel. The impression is very



FAC-SIMILE OF THE LETTER OF FULTON TO THE COMMISSION APPOINTED BY NAPOLEON IN 1803. FROM THE ORIGINAL IN THE CONSERVATOIRE DES ARTS ET METIERS PARIS. FOR THE SECOND AND THIRD PAGES SEE PAGE 413



marchandize. Mais pour les passagers il est possible de juger quelque chose à cause de la Vitesse —

Dans ces dessins vous ne trouverez rien de nouveau, j'imagine. ce ne sont que des roues à eau, moyen que a été souvent essayé et toujours abandonné, parceque on croyoit qu'il donnoit une prise désavantageuse dans l'eau, Mais d'après les expériences que j'ai déjà faites je suis convaincu que la faute n'a été pas dans la roue mais dans l'ignorance des proportions des Vitesses, des puissances et probablement des combinations mechaniques.

J'ai trouvé par des expériences très exactes que les roues à eau sont beaucoup plus favorables au Chapelet, par conséquent quoique les roues ne sont pas une nouvelle application, si cependant je les combine de manière qu'une bonne Moitié de la puissance de la machine agisse en poussant le bateau de même que si la force étoit de la terre; la combinaison sera infiniment meilleure que toute ce qu'on ait fait jusqu'ici et c'est dans ce fait une nouvelle découverte —

Pour transporter des Marchandises je propose un bateau à machine destiné à tirer un ou plusieurs autres bateaux à charge, chacun desquels sera se servira à son davancement que l'eau ne coule pas entre pour faire resistance. J'ai déjà fait cette dans mon patente pour des petits canaux, et il est indispensable pour les bateaux marchands mus par la machine à feu.

Par Exemple

Supposons le bateau a Machine A presentant à l'eau une face de 20 pieds mais pointu à un angle de 30 degrés. Il faudroit une machine de 1,120 ℔ de puissance pour donner 3 pieds par seconde pour le mouvoir une lieue par heure dans l'eau stagnante. Si les Bateaux B et C ont des faces pareilles a A il leur faudra à chacun une egale puissance de 1,120 livres et a dire 1260 livres pour les trois, tandis que si ils sont lies de la maniere que j'ai indiquée la force de 420 suffira pour tous. cette grande economie de puissance est trop conséquent pour être negligé dans une telle entreprise.

Citoyen

Joignez mes

FAC-SIMILE OF THE LETTER OF FULTON TO THE COMMISSION APPOINTED BY NAPOLEON IN 1803. FOR TRANSLATION SEE PAGES 410 AND 411. WITH THIS LETTER WAS ALSO SENT THE DRAWING REPRODUCED ON PAGE 409

strong on my mind that he was in bed with Fulton. Fulton rushed at once to the spot and went into the river himself, and indeed there contracted the disease of the lungs from which he never recovered."

Dr. Hale wrote down this interview shortly after it occurred, and his communication of it is doubtless as close to the actual occurrence as can be had.

The adverse influence which this disaster had upon the commission can well be imagined, and there is little doubt that to this accident is due the fact that an unfavourable report was made.

Fulton, however, was nothing daunted, but instantly began the construction of another boat, and we may be sure that this hull was of ample strength. His efforts at this time were ably seconded by the powerful aid of Livingston.

It was well understood, both in England and in France, that the peace of Amiens was little more than a truce, and both sides were quietly preparing for the war which both knew was inevitable.

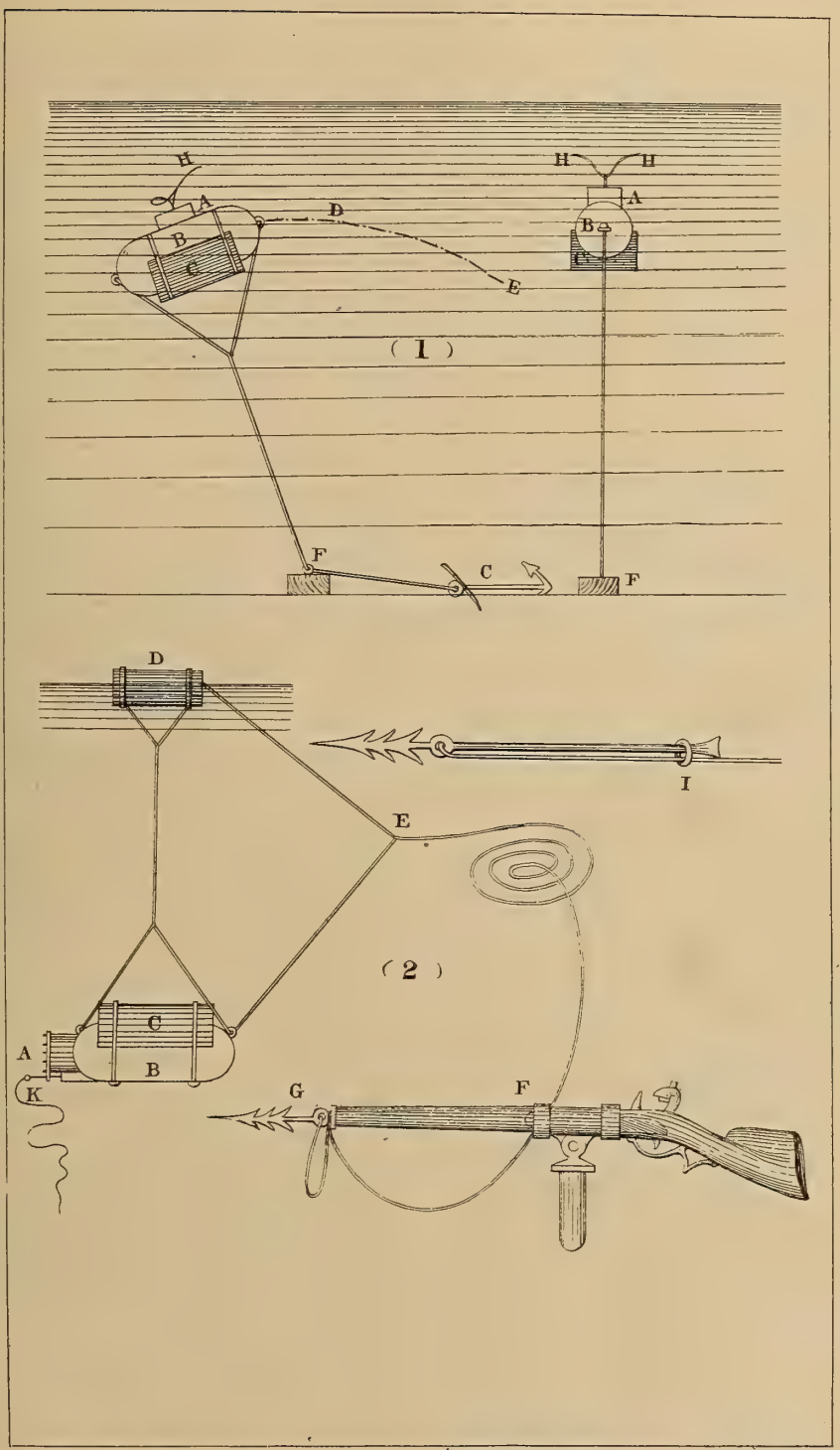
Napoleon, who had purchased Louisiana from Spain, realized that in the coming war with England he would be unable to hold this distant province in the face of the powerful British fleet, and decided to offer it for sale to the United States, thus realizing a substantial sum of money, and delivering Louisiana into the hands of a rival power. Robert R. Livingston had been sent to France as Minister Extraordinary, with especial powers to conduct the negotiations relating to the purchase of Louisiana by his government, and upon his arrival in France he was immediately attracted by the important work of Fulton, and it was by Livingston's aid that Fulton's boat was finally completed. The work of reconstruction, however, occupied all the summer, and it was not until the month of August that practical navigation was effected. Probably the best contemporary account of the successful work of this steamboat is that which appeared in the "Recueil Polytechnique des Ponts et Chaussées, Paris, t. I. 1803."

"On the 21st Thermidor (9 August, 1803), a trial was made of a new invention, of which the complete and brilliant success should have important consequences for the commerce and internal navigation of France. During the past two or three months there has been seen at the end of quay Chaillot a boat of curious appearance, equipped with two large wheels, mounted on an axle like a chariot, while behind these wheels was a kind of large stove with a pipe, as if there was some kind of a small fire engine (*pompe a feu*) intended to operate the wheels of the boat. Several weeks ago some evil-minded persons threw this structure down. The builder, having repaired this damage, received, the day before yesterday, a most flattering reward for his labour and talent.

"At six o'clock in the evening, aided by only three persons, he put his boat in motion, with two other boats attached behind it, and for an hour and a half he produced the curious spectacle of a boat moved by wheels, like a chariot, these wheels being provided with paddles or flat plates, and being moved by a fire engine.

"In following it along the quay the speed, against the current of Seine, appeared to us about that of a rapid pedestrian, that is, about 2,400 toises an hour; while in going downstream it was more rapid; it ascended and descended four times from Les Bons-Hommes as far as the pump of Chaillot; it was manœuvred with facility, turning to the right and left, came to anchor, started again, and passed by the swimming school.

"One of the boats took to the quay a number of savants and representatives of the Institute, among whom were Citizens Bossut, Carnot, Prony, Perrier, Volney, etc. Doubtless they will make a report which will give to this discovery all the



FULTON'S TORPEDOES

Fig. 1 shows a floating contact torpedo for harbor protection. Fig. 2 shows a harpoon torpedo; the case B contains the gunpowder, a clockwork explodes, A is set in motion when the pin K is withdrawn

éclat which it merits; for this mechanism, applied to our rivers, the Seine, the Loire and the Rhone, will have most advantageous consequences upon our internal navigation. The tows of barges which now require 4 months to come from Nantes to Paris, would arrive promptly in 10 to 15 days. The author of this brilliant invention is M. Fulton, an American and a celebrated mechanic."

It was on April 30, 1803, that Livingston closed the negotiations for the purchase of Louisiana for the sum of fifteen million dollars. If Napoleon had devoted but one of those American millions to the development of the work of the American engineer, who can doubt that the effect would have been a controlling one upon the destinies of the world.

Dr. Hale's comments present the situation in a clear and vigorous manner:

"Observe that on the 12th of May, Lord Whitworth, the English Minister, demanded his passports, and that war with England began—the war that ended with Elba. Observe, that on the 18th day of May, 1804, Napoleon proclaimed himself Emperor, and that he had already begun to gather his army at Boulogne and the neighbourhood for an invasion of England. And consider the use he would have made of twenty steam barges."

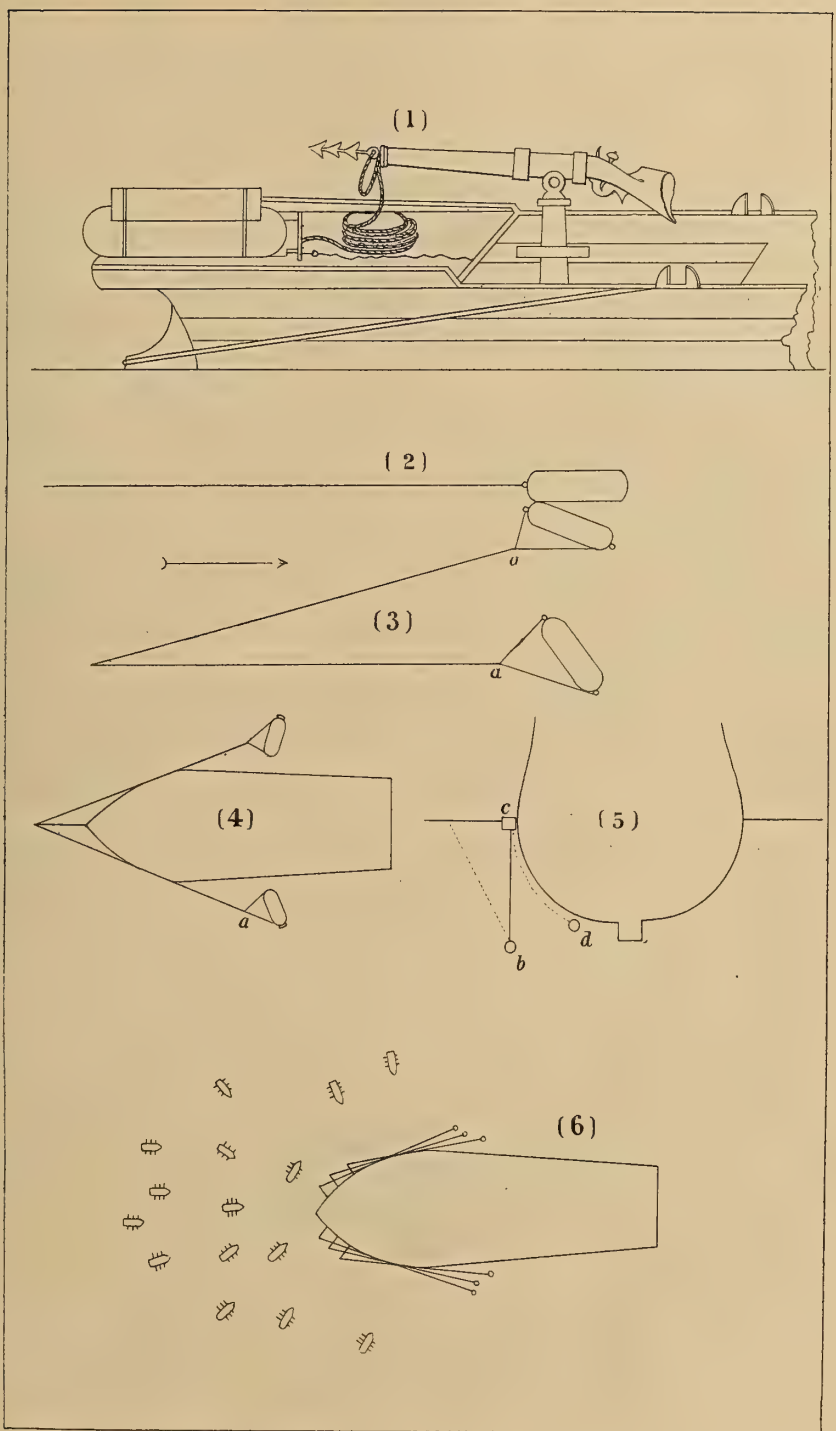
We have already seen how the French historian, Bignon, regarded the influence which the adoption of the steamboat would have had upon the conflict of England with France. Alison, the British historian, is inclined to minimize the importance of the matter, believing that England would immediately have produced steamboats and means of defence which would promptly have offset any advantage which Fulton's steamboats might have given to France.

The late Lord Acton, however, than whom no better critical authority upon the history of the period could be named, was of a different opinion. When, shortly before his death, some one asked him at Cambridge what he considered the most important event in the nineteenth century, he replied that it was the sinking of Fulton's boat on the Seine. He meant, doubtless, that if Napoleon had had Fulton's steamboat to take his flotilla across from Boulogne to England, the history of the world would have been changed.

Fulton now realized that he could expect no appreciation or help from the French government, and he decided to return to England. As his work in France was already known, he decided to use an assumed name in London, and in May, 1804, there appeared in England a distinguished-looking man, bearing the name of Francis, who placed before the British Ministry his plans for the use of submarine torpedoes and plunging boats against the French. With his apparent ease in securing access to men in high places, Fulton, for it was he, soon secured the influence of Mr. Pitt, then Prime Minister, and again he was given opportunity to show a government commission what he could do.

According to the "Naval Chronicle," one expedition was made against the French fleet in October, 1804, and a number of catamarans to which torpedoes were attached, were sent out, but although numerous explosions followed, no serious damage was inflicted. A year later a more vigorous attack was made against the chain of French gunboats at the port of Boulogne, and the following report, taken from the "Naval Chronicle," for 1805, gives the French account of the attack. The French commander reported it as an attack of British "fire ships," little thinking that it was really an attack of Fulton's torpedoes, but such was actually the case. It was Fulton's farewell to the country which had so utterly failed to appreciate him.

We give the report of this attack in full as it was published in the "Naval Chronicle" in London.



FULTON'S TORPEDOES

Fig. 1 shows a torpedo boat, with harpoon torpedo ready for discharge. Figs. 2, 3, 4. 5 indicate the various methods which the torpedo may swing around the attacked vessel. Fig. 6 illustrates an attack of a number of torpedo boats against a frigate.

Extract from the "Naval Chronicle," Vol. XIV., p. 339, 1805.

FROM THE FRENCH PAPERS.

Ministry of Marine,

BOULOGNE, Oct. 1, 1805.

I have the honour to inform your Excellency that the day before yesterday the Line of His Majesty's Flotilla, consisting of 27 Gun-boats alone, under Captain Dordelin, had the whole day 23 Vessels in front of them, two of which were of the Line, four Frigates, and the rest Cutters. Yesterday the Enemy had not diminished in number; but accustomed to see them in such Force, I did not think it necessary to reinforce our Line, convinced that it was sufficient to repel all attacks.

At midnight, the weather being very thick, and the Sea calm, I heard a warm firing, and some discharges of cannon in the Line. I made immediate dispositions for several Divisions of the Flotilla to go out, but the firing having ceased, I suspended that movement. Proceeding along the Line Captain Dordelin informed me that the Gun-boat No. 62, head of the Line to the East, commanded by Ensign Alex, had been surrounded by a chain of Fire-ships conducted by several pinnaces.

That Officer, without slipping or cutting his cable, which would successively have exposed the whole Line to danger from the Fire-ships, kept his Post firmly; and directing all his efforts to the chain which connected the Fire-ships, he attempted to break it, and succeeded.

The chain being broken, the Fire-ships defiled along the Line. Yet the Gun-boat No. 306, Captain Nivelain, was grappled by six of them. That Officer performed the same manoeuvre as Captain Alex, and his second in Command and two others jumped into the Boat and disengaged the Vessel.

But one of the Fire-ships having exploded near the Gun-boat, she was thrown up and covered with water, and had no other damage than her windows broken and some shot aboard.

No. 291 also experienced the effects of the blowing up.

The Gun-boats No. 280, 305, 138, 34 and 61, were more particularly attacked but did not quit their Post.

Some of the ropes were merely cut by the balls, and the Enemy's Pinnaces repulsed by a warm firing, soon took to flight and were indebted for their safety to the darkness of the night. At two o'clock all was quiet along the Line, and we had not a man killed.

At day-break Captain Alex, having perceived some articles floating sent his Boat with six men for them; they brought back a spherical machine, copper sheathed, and which was found to be one of the infernal machines, called by the *Moniteur, Globes of Compression.* As it was being conveyed on shore it blew up, and the Midshipman Meisurier and three men perished. At low water we found on the coast several wrecks of the Fire-ships, and particularly a lock like that of the Fire-machines which the English used last year. with as much ridicule and as little success.

The Rear-Admiral, Commander-in-Chief of the Imperial Flotilla. LACROSSE.

According to a statement made in Parliament several years afterwards by Earl Stanhope, an agreement had been made by Mr. Pitt and Lord Melville with Fulton, by which the latter was to receive £40,000 for his services in this matter. In view of the fact that the attack was but partially successful, the amount was referred to arbitration, and ended in Fulton being paid £15,000, which sum doubtless was fully absorbed by his expenses.

Although this was Fulton's last appearance in connection with France, one more reference to his work in Europe may be permitted. Mr. Pitt still believed in him, and agreed to give him one more opportunity. A Danish brig, the *Dorothea*, was anchored off Deal, near Walmer Castle, and on October 15, 1805, Fulton sent out a torpedo and utterly destroyed the vessel, exactly at the appointed time, before a large concourse of spectators, including the commissioners and many naval and military officers. The general feeling in England, however, was that anything which encouraged submarine warfare and torpedoes was simply acting against Britain's supremacy on the seas, and the prevailing opinion was fully expressed by Earl St. Vincent, who, after the destruction of the *Dorothea*, said: "Pitt was the greatest fool that ever existed, to encourage a mode of war which they who commanded the seas did not want, and which, if successful, would deprive them of it."

After Fulton left France the course of affairs shifted to such an extent that it is probable that had he remained there would have been little or no opportunity for him. The formation of the coalition of Austria and Russia against Napoleon compelled him to break up the camp at Boulogne and transfer the seat of war to central

Europe, where the surrender of Ulm and the victory of Austerlitz broke the coalition, but at the same time effectually diverted him from his plans for the invasion of England.

In October, 1805, only a few days after Fulton had demonstrated the power of his torpedoes before Pitt, Nelson won the great naval battle of Trafalgar, utterly destroying the combined fleets of France and Spain, and disposing forever of any pretensions which Napoleon might have had to attain naval power. The opportunity for France to profit by the advantage which Fulton had placed before her was gone, and the development of steam power in naval service became the common privilege of all nations alike.

Fulton left England, sailing from Falmouth in October, 1806, and arrived in New York, by way of Halifax, on December 13, after an absence of nineteen years from his native land. In the following year the *Clermont* began her successful career on the Hudson. Thus the efforts which, amidst the stormy times of the French Revolution, and the Napoleonic wars, seemed destined to transform naval warfare, were more fortunately diverted to the peaceful uses of commercial transport in the new world.

At this late date it is easy to criticise the blindness of Napoleon and his advisers, but history repeats itself, and it is a question if, to-day, any such innovation in the recognized methods of warfare would meet with any fuller recognition. Naval and military prejudices are as strong as ever, and while governments are indeed inclined to experiment with submarine boats, with dirigible balloons, aeroplanes, etc., the path of the civilian inventor is still a difficult one when it is directed into official fields. Practically the whole of Fulton's career in France was a continual effort against official prejudice and opposition, while its diversion into the development of commerce and navigation in peaceful transport was attended with immediate success.

THE PROMOTION OF EMPLOYEES

By J. F. Gairns

THE selection and advancement of employees is a question of the utmost importance in modern commercial and industrial business, but it is complicated by so many side issues and it is so difficult to classify its various aspects that the following remarks can only be considered as an attempt to review the main features of policy in reference thereto as they affect the employee and the employer.

As regards the employee, the writer proposes to consider the relative importance of the various qualifications for promotion, bearing in mind also the great differences which are created by the different professions and industries, though there is really more standardization in this respect than may appear at first inspection.

As regards the employer, the same factors will be considered, but from a different aspect, though there is considerable correspondence between them in most cases, with the object of setting forth what are in the writer's opinion the main considerations which should govern an employer's policy in reference to the promotion of his employees or the alternative introduction of outsiders to fill vacant positions or new posts.

In all cases a ruling consideration will be that a modern business is a moneymaking concern and not a philanthropic institution.

In default of a satisfactory method of classification the various qualifications for the promotion of an employee will be first considered, both from the employee's and the employer's standpoints, concluding remarks dealing more specifically with the advantages and disadvantages of the "promotion," and "outsider" policies, favoritism and influence and a few general features of the whole subject.

SENIORITY

For the purposes of our subject this may be considered as a qualification, though it is an impersonal one.

In large establishments where many employees are engaged on the same or similar work capable of classification in a few main divisions, promotion by seniority may, and often does, answer fairly well, but as a general principle it is unsatisfactory both from the employee's and the employer's point of view. Such a policy tends to mechanical work; initiative is at a discount; the incapable man has as good chances as the capable man, though the latter usually has to make up for the deficiencies of the former, but without corresponding advantage; work may be neglected or indifferently performed and, so long as he does not go too far, an employee is in a fairly safe position, while superior officials are comparatively helpless in dealing with the matter, even if they are inclined to do so, which is frequently not the case; work is done without thought as to its bearing on other sections; and altogether a premium is placed on incapability, while capability tends to become degraded. It is true that where promotion by seniority obtains a few opportunities must also occur for promotion for other reasons, but unless such opportunities are fre-

quent, what has been said above is substantially correct.

As an example of the above, civil service departments may be instanced, though in some cases the actual work required to be done tends to prevent some of the unsatisfactory features mentioned becoming characteristic. A usual and almost inevitable corollary to the promotion by seniority policy, and one which is most prominently associated with civil service departments, is the fact that in such cases employees are rigidly classified in grades, and it is extremely difficult for an employee to become transferred from one grade to another, except in early years when examinations are available.

Promotion by seniority possesses some good features, but not many, and where it is satisfactory it will generally be found that other factors are really responsible.

HONESTY

Of the personal qualifications this is undoubtedly the one to be considered first, but in practice, unfortunately, honesty is not always the most important.

For positions of trust and where the person concerned has to be trusted to work for the welfare of his employer though he has opportunities for doing otherwise, honesty is most important. But cases are common where a man is promoted for capability without special honesty or in order to ensure his honesty because it is to his interest to be honest. It is not always the honest man who is promoted, even if he also possesses other qualifications, and there is many an instance where the man noted for his honesty is still in a subordinate position while others less morally trustworthy have been promoted over his head, maybe time after time. The truth is that where honesty is all important, then the honest man has a special opportunity, but where dishonesty is made difficult, then it is other capabilities which govern promotion.

ORDERLINESS, NEATNESS, CORRECTNESS AND PAINSTAKING WORK

These are very desirable qualifications, but they are sometimes somewhat out of place. A man who possesses these characteristics is very useful for some kinds of work, bookkeeping on a large scale especially, but in many instances these are subordinate requirements. It very often occurs that the orderly clerk, or the splendid writer or the absolutely correct accountant is rather superfluous. System and checking will discount these capabilities to some extent, especially if averagely capable men are available whose mistakes are few and far between, while the typewriter has placed handwriting in a very secondary position. Moreover, it is very unusual that these capabilities tend to mediocrity in other respects, for the man who is scrupulously exact in everything, sometimes superfluously so, is often too much concerned with details to be able to grapple with matters of serious importance and emergencies.

In industrial work these characteristics are important, for they usually make good work a certainty, but even there it often occurs that they also entail slowness of production and sometimes make work unprofitable. The work when done may be eminently satisfactory, but in very many cases work less perfect is equally satisfactory.

RELIABILITY

There is reliability and reliability. The man whose work can be depended upon without supervision, especially in respect of details, is a very useful assistant, for he leaves his principals and superiors free to deal only with main items. But even in this connection there is another side, for associated with reliability one often finds a narrowness of ideas, an indifference to things with which the reliable individual is not concerned, and a tendency to labour detail considerations in preference to broader matters.

THOROUGH KNOWLEDGE

For good work this is essential. The man who half knows his work rarely possesses many other qualifications for promotion; but thorough knowledge is only obtained by understanding as distinct from mere routine learning. There are many employees who can do one thing perfectly, simply because they are always doing it, but this only qualifies them for similar positions, and thorough knowledge implies more than this if it is to be a qualification for promotion.

SPECIAL KNOWLEDGE

This usually implies that a man has exercised initiative and capability and that he realizes that to possess special knowledge is to render himself eligible for special positions. In a narrow sense this amounts to specialization and is not a qualification for promotion, except when a special man is required to do special work; but in a broader sense specialization means that a man has made himself master of a particular branch of industry in order to make himself indispensable or an acquisition to an employer. In many cases such a specialist develops his own promotion, for by proceeding on special lines a desirable position is often created as business develops.

COMMON-SENSE OR "GUMPTION"

The candidate for promotion should cultivate this qualification. While a man is only one of many doing the same or similar work, a general knowledge of his work is usually sufficient to carry him through, but it is this indefinite quality, often termed "gumption," that lifts a man above his fellows and enables him to cope with difficulties. Many a man with indifferent training or experience is really a better workman than men who have had the best of training and long experience, simply because he can use his brains to help his hands, and because he can see a little way beyond his nose.

INITIATIVE

In many respects this is the same as the preceding, but not wholly so, for initiative goes a step further. A man possessing "gumption" can deal with what comes before him, but an initiative man will often develop beyond that. Moreover, an initiative employee quickly becomes a marked man for selection for favoured work, and, as opportunities occur, for promotion also, for he can deal with matters which arise out of his work as well as with the work itself. Further, he is naturally a leader of men, and this alone is a qualification for a controlling position.

ORIGINALITY

This again corresponds very closely with "gumption" and "initiative," but proceeds a step further. An initiative man can originate developments, but the man who possesses originality can often introduce a new method of doing things, a new system, or can effect improvement in existing methods and systems.

In inferior positions originality is sometimes at a discount, for new methods and systems are not desired or required, but in superior positions, and especially after the early stages of promotion have been effected, it is the man with originality who comes to the fore. There is, however, a limit to originality as a valuable asset. If carried beyond applicability and due regard for existing methods and circumstances, the original man may be somewhat of a nuisance, but in such cases it generally means that there is originality without "gumption."

The remaining qualifications for promotion belong to a somewhat different class.

SUPERVISION, MANAGEMENT, AND CONTROL CAPABILITY

These are undoubtedly the principal qualifications for promotion, for although it occasionally happens that a promoted man occupies a superior position solely in reference to his own

work, as a rule promotion also entails control over one or more assistants, and the promoted individual is generally brought into connection with other people's work or the work of other departments.

It does not always follow that the best workman is the best man to control others on that work, or that the best controller is the best workman. Indeed, the reverse is more often the case. The old proverb "Practice what you preach" is a very praiseworthy and generally correct maxim, but it often happens that the person who is most capable of directing and supervising the work of others is only an average worker himself. In fact, it is not always necessary that a good controller shall even know the work in all its details, but as a rule such knowledge is essential to efficient management and control.

Management and control capabilities are to some extent natural gifts, but they can be cultivated, and without such capabilities it is unlikely that the most honest, conscientious, painstaking, correct and reliable man will be a managerial success. Things may go smoothly, but unless there is managerial capability, a department thus controlled lacks strength and consistency.

It is therefore probable that many apparently unfair promotions at the expense of long-service trustworthy men are really evidences that an employer has acted most judiciously in the interests of his business.

In addition to capability for the management and control of men or of a section of work, self-management and self-control are also necessary for efficiency. There are many instances where the personal equation of the manager or controller is quite as important as regards himself as it is in reference to those under him.

TACT

How many promoted individuals have come to grief because of want of tact, it would be impossible to estimate; but the man who has tact usually controls a harmoniously working and efficient department. It is tact that enables him to deal with those under him, with those on an equality with him, and with those above him in such ways that harmony is maintained, work progresses smoothly, and his department develops.

Having thus considered the various qualifications for promotion, their relative importance as they appeal to an employer must now be dealt with, though briefly. For this purpose we must consider that a model employer is in question who considers things principally from a strictly business point of view, though with some humanitarianism, and who is capable of estimating things in a fair and unbiased manner.

Honesty, conscientiousness, painstaking work, reliability, neatness and orderliness are very desirable, but there is many a man possessing all these capabilities who is continually being passed over for promotion. As a rule he is quite unable to understand why this should be, and is correspondingly aggrieved. But his employer, and probably also many of his confrères, know that he does not possess initiative, management capability, and capacity for responsibility. Many a man by his experience has shown the truth of the saying, "A good servant may be a bad (or incapable) master," and conversely there is equal truth that "A bad servant sometimes makes a good master."

As soon as one takes a leading position, it may be as foreman of a department, clerk in charge of an office section, storekeeper, chief draughtsman, or it may be as a district representative traveller, works manager, or general manager, then the primary requirements are, given knowledge of the work, initiative management capability, common sense or "gumption," and, above all, "tact." For real satisfaction, the other characteristics previously mentioned are necessary in a degree, and honesty and

conscientiousness are generally required as a sine quâ non, but initiative and capability are really more important.

When, therefore, a level-headed and fair employer has to fill a special post, or is creating a new position, he has to decide, not merely which employee most deserves promotion, but which employee is most capable. And sometimes the best solution is the introduction of an outsider. In the case of assistants who have developed their own work, or where promotion is the natural outcome of circumstances, no difficulty is experienced; but such cases are really outside our subject.

In many businesses, and especially in those associated with particular industries, the practice is to promote employees very rarely, if at all, outsiders being introduced to fill vacancies in preference; and there is a good deal to be said for such a policy. And when it is a general or fairly general policy, little or no hardship is entailed upon the employees; for although they may not be able to obtain much promotion by staying with particular employers, they are eligible for special posts with other employers, and are often specialy fitted for them.

A man who is promoted over his companions is not always in a desirable position. His previous equals resent his superiority, and he himself is at a disadvantage in dealing with them. And his previous superiors cannot or will not always adapt themselves to the new conditions, nor can he always do so on his side. By changing his employer, however, a man is often able to show his capabilities in a way that he could not do by remaining in one employ even if promoted. We thus have, besides the question of the promotion of employees, an alternative policy, that of the introduction of outsiders for special positions, forced upon our consideration, and it will be interesting to briefly summarize the advantages and disadvantages of the two policies.

I. PROMOTION OF EMPLOYEES.

A. Good service and merit are rewarded.

B. An employee is encouraged to do his best for his employer.

C. Promoted employees are familiar with the ins and outs of their employer's business and with peculiar methods.

D. Employees develop with their employer's business.

E. Encouragement is given to employees.

F. The interests of an employer become those of his employees.

II. INTRODUCTION OF OUTSIDERS.

A. A man occupying a promoted (to himself only) position, is free to show his capabilities.

B. Men become familiar with the methods and practices of more than one firm.

C. Knowledge is extended.

D. Employers benefit from the introduction of men having experience other than their own.

E. Knowledge, capability and experience are at a premium.

On the other hand, the disadvantages of the two policies may be similarly expressed:

I. PROMOTION OF EMPLOYEES.

A. Non-promoted employees may be aggrieved and disheartened.

B. The promoted employee is not necessarily the most capable one, though he may be the most deserving.

C. There is a tendency to stagnation, for a promoted employee usually carries on the methods and practices of his predecessor.

D. A promoted employee may occupy an anomalous position in dealing with those below and above him.

II. INTRODUCTION OF OUTSIDERS.

A. Employees passed over by newcomers may be aggrieved and disheartened.

B. The newcomer is somewhat of an interloper, and though he knows

his work, he does not know the peculiar methods of his new employers.

C. Other ideas or familiarity with other methods will not always work well with those of the fresh employment.

D. A new man can quickly make enemies of those with whom he has to work, or with those below or above him, but is less easy to change them to friends.

E. The interests of employees need not coincide with those of an employer.

It will be seen that in both cases (a) is the same, but when the introduction of outsiders is a usual policy, it is of little importance, for when it is known that particular men are introduced for particular positions, inferior employees realize that their own opportunities are to obtain similar positions somewhere else.

So far we have considered that employers are always judicious and level minded, and that they act rightly and for the good of their businesses, humanitarianism being only introduced where it agrees with commercial acumen.

But, unfortunately, not all, or nearly all employers fulfill these conditions, any more than all employees possess the required characteristics which render them eligible for promotion.

Many an employer acts injudiciously in regard to the filling of vacant positions. Sometimes humanity overrides proper business consideration. Sometimes the maxim that "a money-making concern is not a philanthropic institution" is carried to an extreme. In other cases the claims of kinship, friendship or acquaintanceship, influence and favouritism override the claims of merit, capability and fitness for a post. Further, it is nothing unusual for personal liking, prejudices, or idiosyncrasies to overweigh judgment. Also there are many cases where principals or superior officials have the responsibility of decision without having the facilities for proper knowledge to guide them; and in other cases superior but subordinate officials can exert an influence that militates against the promotion of those employees who should be considered, and the writer has seen it seriously argued in reference to a large business having many ramifications, that it is better for a subordinate to become known to his principles for his misdoings than not to be known at all, for sometimes where applicants for promotion are all unknown, it may be that the familiarity of a name, the cause for such familiarity being overlooked or forgotten, may be the sole reason for a particular promotion.

It therefore behooves all employers, particularly those in control of extensive businesses, or chief officials themselves, responsible for the promotion or otherwise of employees beneath them, not only to act with proper regard to the well being of business, but also with proper regard for their employees or subordinates.

Having thus reviewed briefly the principal considerations which affect this subject, a summary can be made as follows:

(1) In ordinary routine and mechanical work, the promotion of employees is a general practice. In fact, in the usual way, it occurs in the natural course of events and development.

(2) For superior positions, where knowledge of methods and practices of a particular business, as distinct from the practices of businesses of similar kind, are concerned, promotion of employees is best for the reason that the man who has worked up is usually the only one who can know the details necessary for control.

(3) For superior positions, where knowledge of the methods and practices of a particular trade or industry, as distinct from the methods and practices of a particular firm, are concerned, the introduction of outsiders is very often a preferable policy.

(4) Honesty, conscientiousness, careful and systematic work, and like characteristics, while desiderata, are

not necessarily the only or the principal credentials for promotion, though honesty and whole-heartedness may be said to be requirements in all cases.

(5) Managerial and controlling capabilities, initiative and tact are, as a rule, more important reasons for promotion than the characteristics set forth in (4).

(6) The combination of (4) and (5) though rather rare, should provide a practically certain argument for promotion.

(7) Humanitarianism and regard for employees should be introduced as far as possible, but in a money-making concern may not always conduce to the well-being of a firm, if carried to an extreme.

(8) Initiative and originality should be encouraged.

(9) The interests of an employer should be, or should be made to be, those of his employees.

(10) Harmonious relations should be cultivated between employer and employee, and between superior and other employees.

(11) Promotion, if a recognized policy, should be made with discretion, and with due consideration as to the possession of the necessary qualifications by the employee promoted.

(12) If promotion is not a recognized policy, usual methods should not be departed from without very good reason. At the same time the promotion of a specially capable man will probably give general satisfaction.

(13) Specialization is good to a degree, but should not be a fetish with employees.

(14) Favouritism, influence, personal bias, prejudice, unreasonable selection and the claims of kinship or acquaintanceship should not be factors in deciding as to the promotion of employees. It sometimes occurs that such promotions are justified in practice, but that is due to the fact that the man promoted or appointed possesses the required capabilities.

(15) Just as the possession of certain characteristics in that others may be a bar to promotion of an employee, so judiciousness and level-headedness, with proper consideration before action, are required in the case of an employee or of officials responsible for promotion of employees or the introduction of outsiders.

A good deal more could be said on this subject, but enough has been said to indicate that the responsibility of the employer in deciding as to his promotion policy is great, while the characteristics required to fit an employee for promotion are also varied. As regards an employer who does not possess the necessary qualifications for correct decision, it is impossible to lay down any rules or to systematize the situation, though it is hoped that perusal of the foregoing may be useful in some such cases.

THE FLASH STEAM GENERATOR

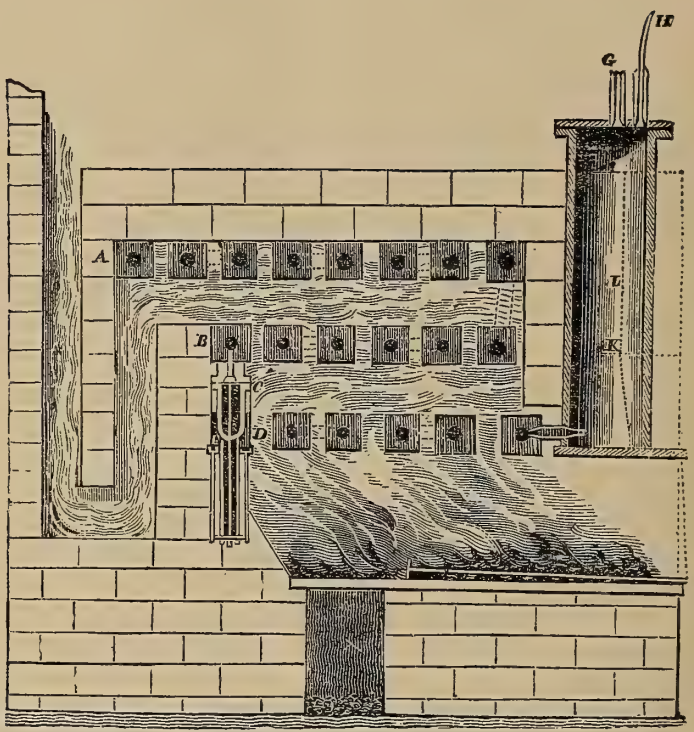
By H. W. Bolsover

Although the idea of generating steam by contact of water with highly heated surfaces is by no means new, it is only recently, in connection with the design of automobile vehicles, that this method has received extensive practical application. Mr. Bolsover discusses the subject especially from this viewpoint, and it appears that for such purposes the flash steam generator is entirely applicable, but that it must be considered upon its own merits and on its own account, and not confounded with ordinary steam boilers as applied to similar service.—THE EDITOR.

THE idea of generating steam instantaneously by delivering water into a highly heated vessel has doubtless occurred to many persons, and indeed it is naturally suggested to almost any one who has ever observed the behaviour of water falling in small quantities upon hot metal. Among the early types of generators intended to utilize this principle we may note the so-called "steam chambers" invented by McCurdy in 1824. This device, as shown in the illustration, consisted of a sort of retort *a*, with thick walls, made of wrought iron, the water being delivered through a perforated nozzle *b*, into the large end, and the steam drawn off at *d*. A number of these chambers, placed side by side in a furnace, constituted a boiler. The practical defect of this device appeared to be insufficiency of heating surface, and it was soon abandoned. About the same time, Paul, of Geneva, proposed a flash boiler consisting of a conical spiral of copper pipe set over a furnace, the water being forced into the spiral by a feed pump, and flashed into steam. Curiously enough, M. Paul suggested this device as suitable for a steam carriage.

The veteran inventor and experimenter with high-pressure steam, Jacob Perkins, also devised a flash boiler, and the apparatus shown in the illustration was made by him in 1824. The tubes of this boiler were of cast iron, square outside with a small bore, these tubes being laid across the furnace and connected outside the walls so as to form one continuous pipe. The water was forced directly into the two upper tiers of tubes and there highly heated, but, owing to lack of space, it could not flash into steam until it was delivered into the lower tier. The steam thus formed, was delivered into the vertical steam chamber. The fact that Perkins had to make his tubes of cast iron shows

MC CURDY'S STEAM CHAMBER, 1824



JACOB PERKINS FLASH BOILER, 1824

that the real impediment to the production of a satisfactory flash boiler at that date lay in the material, and it is only since the manufacture of tubing has reached its present perfection that modern flash boilers have been made practicable.

The flash generator is so totally different in its action from any other form of steam raiser that it becomes necessary for those who have the charge or management of a flash generator plant to forget entirely (for a time at all events) all they ever knew about the ordinary multitubular or water-tube types.

The flash generator was designed to meet a want by which high steam pressure could be carried with absolute safety from explosion even in the hands of inexperienced or careless users. The construction of the modern instantaneous generator is extremely simple in its design. The principle adopted and now most generally in use is that of stacks of cold drawn weldless steel tubing, each element of the stack being bent in a gridiron or circular form, into which water is injected by means of a suitable force pump.

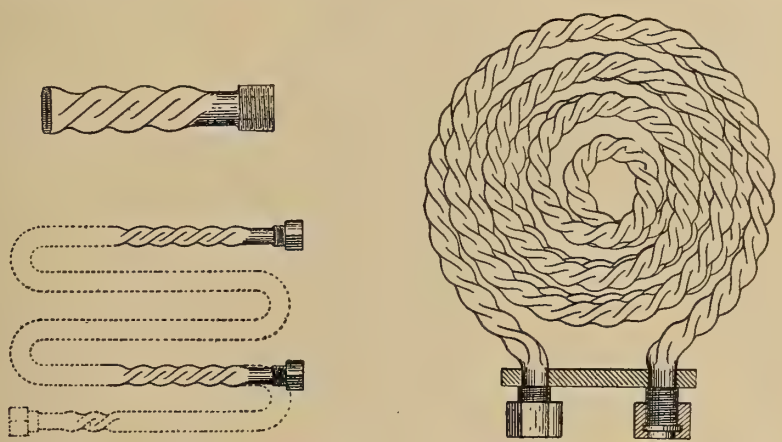
The coils are first heated to the required degree; this of course can be done by various means, perhaps the most convenient and safe method being that of the Bunsen type paraffin burner. Petrol, as well as paraffin, is now largely in use for automobile purposes. The latter fuel, although perhaps not quite as clean in its use for this purpose, holds many advantages over the former, as regards safety, cost, and heat giving properties, and is also more easily procured.

Coal and coke have been found to give remarkable results for launch and stationary purposes. Where it is necessary to have a light, rapid-steaming generator, as on road vehicles, shallow-draught boats, etc., the tubes

of the generator must of necessity be kept of light gauge, and it has been found that it is essential that a system of proportional feed to the fuel and water be introduced. This is effected by several very ingenious methods, which I will endeavour to explain. It must be remembered that excessive overheating of the generator coils is a thing to be avoided, for two reasons, one of which is that with an overheated generator the output of steam becomes considerably reduced, by reason of the water flying off the overheated surfaces without being converted into steam. Secondly, the life of the generator, engines, and packings would be shortened. Therefore, the exact proportioning of the water to the generator and fuel to the burners fulfills a double service, viz.: The desired degree of superheat is maintained, also a steady and constant steam pressure.

A steam donkey-pump is one of the methods of automatically proportioning the feeds, the water and fuel pumps being driven from a specially designed, self-starting, double-acting steam cylinder, giving usually a proportion of one part of oil to ten parts of water. This pump is automatically controlled by means of a diaphragm which is spring-loaded and can be set to come into action and cut steam off the pump at any desired pressure.

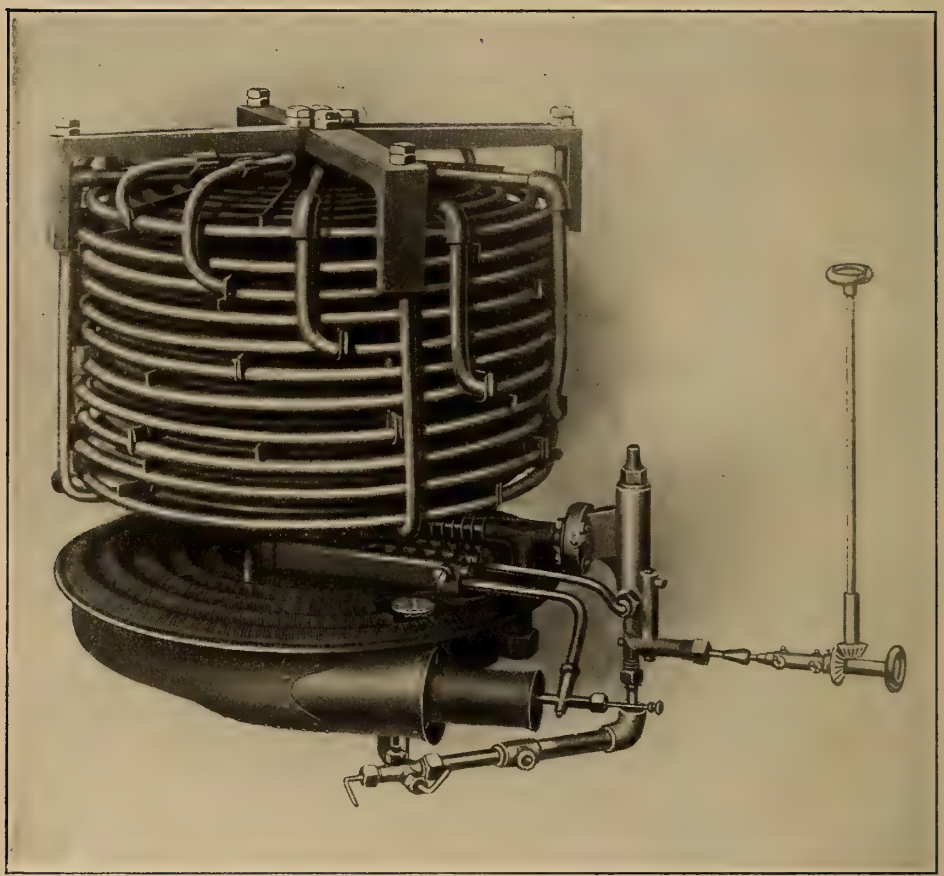
There are several other fuel and water controls on this system, one of which has pumps driven from an eccentric on engine or countershaft, with a stout spring working direct on pump rams so arranged that when an excessive pressure has been reached the spring becomes compressed and the ram temporarily thrown out of action—and as soon as the pressure drops in the generator the pump at once resumes its work.



THE SERPOLLET FLASH GENERATOR, AS ARRANGED FOR AUTOMOBILE SERVICE. THE HEAVY TUBE IS FLATTENED AND TWISTED, SO AS TO OFFER A LARGE SURFACE IN PROPORTION TO ITS VOLUME

For larger plants, in which coal or coke is employed as fuel, and in which weight is no object, tubes of a heavier gauge can be used to advantage. In this case the superheat can be reduced by an ingenious method by which the direction of flow of water is so arranged, to be gradually worked further from the more heated surfaces, till eventually the steam is delivered from the uppermost or coolest elements of the generator.

In some cases, in which petrol is employed as a means of heating the generator coils, a thermostat is employed to reduce the superheat to the desired temperature. This is constructed in the following manner: A rod of expansible metal, such as cop-



THE WHITE FLASH STEAM BOILER, AS USED IN THE WHITE STEAM MOTOR CAR

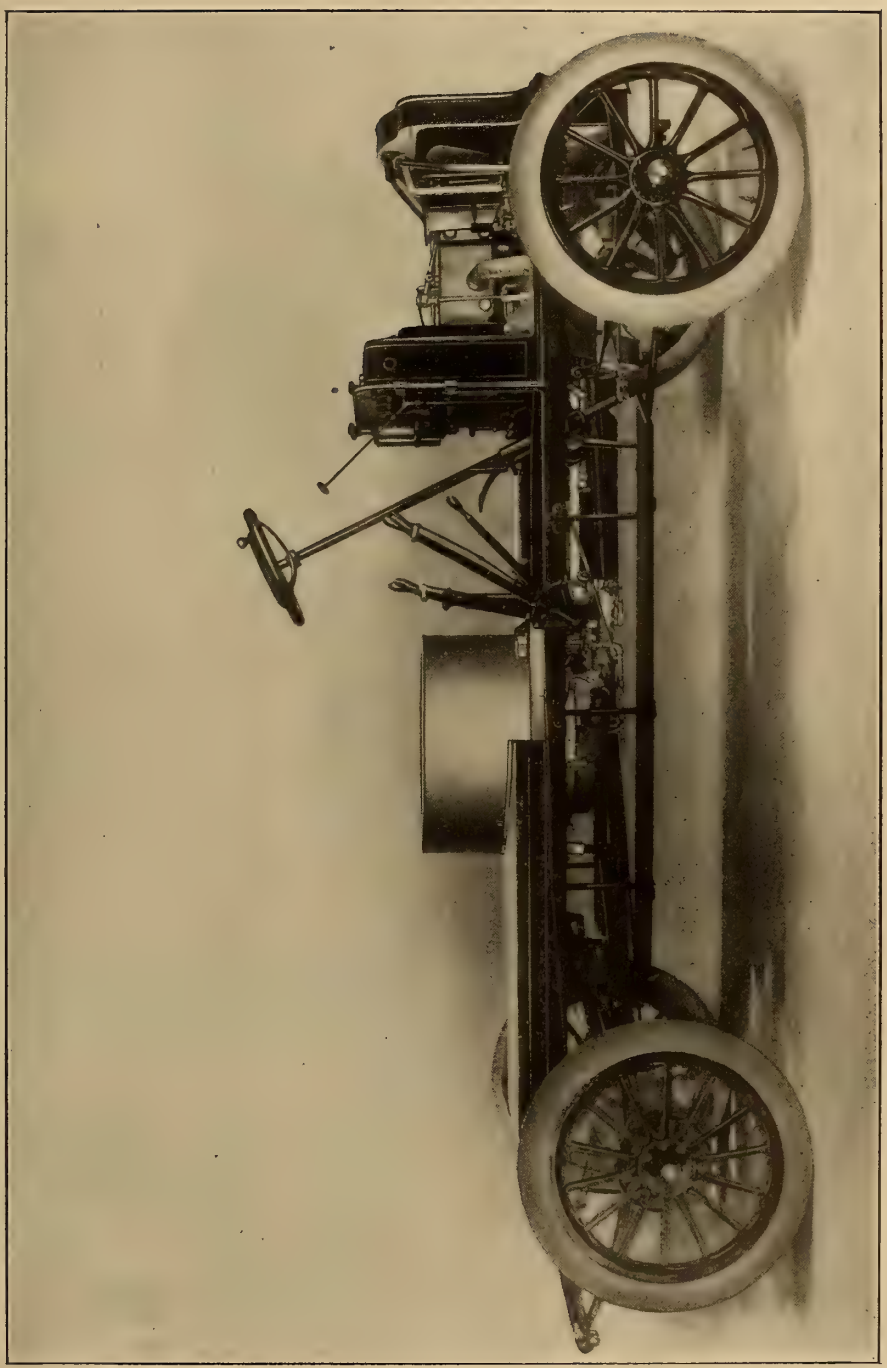
per, is connected to a block of less expansible metal, such as steel. This is placed over the burner, and when the steam which passes round the metal rod (or tube, more correctly speaking) has reached a certain temperature the expanding copper closes a needle valve on the fuel supply pipe, and thus an even superheat is maintained.

It will be acknowledged that one of the most fruitful sources of trouble with any type of boiler now in general use, whether of the water-tube or multitubular type, is the continual corrosion, which must inevitably set in from the very commencement of its existence. Now, one of the peculiarities of the flash generator is that the circulation is so exceedingly rapid that incrustation of any kind is absolutely unable to form in the bore of the tube, as the action of the hot gases has a most peculiar effect on the inside wall of the tube, which after having been in use a short time becomes oxidized.

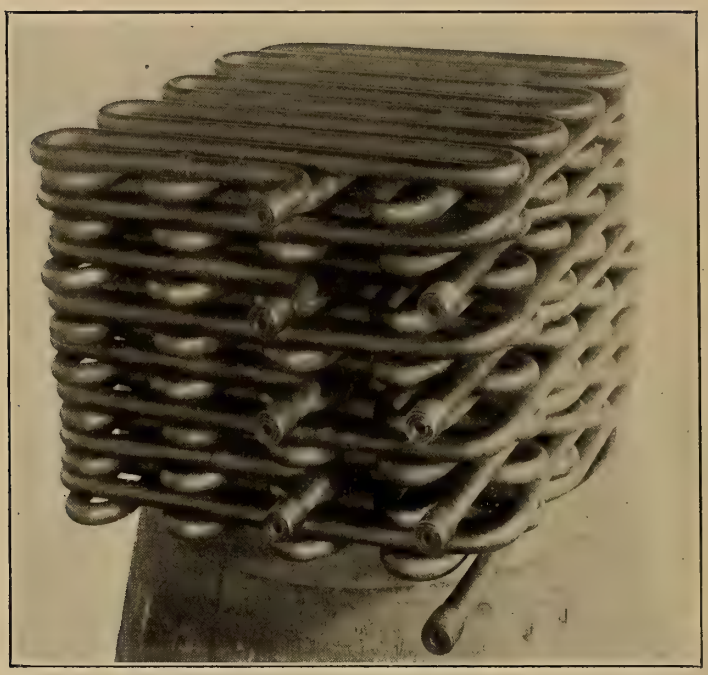
This oxidization protects the bore of the tube in such a manner, that water can be allowed to stand in the tubes without any corrosion taking place.

The superheated steam given off by these generators, which of course is more of the nature of a gas before it reaches the engines, gives, as may be readily imagined, greater efficiency and economy in working. The exhaust is also very much more readily condensed, which is in many cases very desirable.

The three leading makes of steam



CHASSIS OF WHITE STEAM MOTOR CAR, SHOWING ARRANGEMENT OF GENERATOR

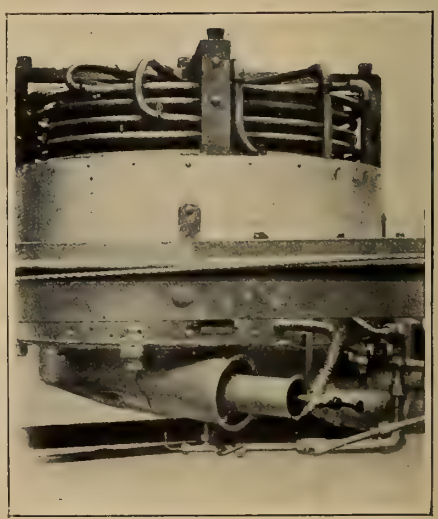


TURNER-MIESSE GENERATOR, 10 HORSE-POWER

"Serpollet," "White," and "Turner-Miesse," each system being totally different from the other, not so much as regards the generation of the steam, but in the methods of fuel and water regulation.

Serpollet, on his system, has the fuel and water pumped in proportion, the water passes from the pump through a large feed-water heating coil, heated by the exhaust from the engine, which therefore performs the double function of partially condensing the exhaust, at the same time heating the feed to nearly boiling point before entering the generator. On leaving this feed heater, the water enters the top coil of the generator then down to a coil of tubing round fire-box, which is also termed feed-water heating coil, from this coil up through the four coils or so immediately over the burners, from thence up again to the top coil but one, then the flow of the steam (or more correctly speaking, gases) is steadily downwards until it reaches the engines.

In the White cars the generator is on the semi-flash system, that is, each coil is so bent as to form a series of traps, each arm of the separate elements being brought up to the top of the generator, and thus the water is



WHITE GENERATOR, WITH UPPER PART OF CASING REMOVED, SHOWING COILS

gradually cooked, as it were, on its way down the generator. Water enters at the top and is forced gradually downwards until it issues in the form of superheated steam, from the lowest coil over the burner. A thermostat is employed on these cars for maintaining the desired degree of superheat, the working of which I described briefly earlier in this article. The pressure of the steam when it reaches about 375 pounds, puts into action a spring loaded diaphragm on the feed-water pipe, and the water is returned to the tank through a bye-pass. Petrol is employed on this car as a means of heating the generator coils.

The Turner-Miesse car has been designed with a view to be entirely hand operated and to do away with automatic appliances. The generator has, therefore, to be made somewhat larger than than the two above mentioned cases. The flow of the water in this generator is somewhat similar to that of the Serpollet. The pressure can be varied by the driver by admitting more or less water to the generator; this is done by a small hand operated by-pass valve, under ordinary conditions, as steaming on level roads the engine pump being designed sufficiently large is continually bye passing water back to the tank (or not delivering water to the generator up to its full capacity) and boiler having ample reserve full output from the pump can be delivered to same on arriving at a hill. Ordinary paraffin is used as fuel. The engines are of the single acting type, having three cylinders running in oil.

THE USE OF STEEL IN LOCOMOTIVE CONSTRUCTION

By F. A. Lart

At the present time steel is undoubtedly the most widely used material known in mechanical construction. The broad meaning of the term steel, however, is sometimes misleading, and it has become necessary to examine carefully the various alloys bearing this generic name if the most efficient use of material is to be secured. Mr. Lart calls attention to the fact that in the development of the modern steam locomotive much greater strength and structural efficiency might be secured by the use of the newer alloy steels, especially if the material were in each instance selected with especial reference to the stresses acting upon it. By permitting a reduction in the factor of safety without actually diminishing the safety itself, increased power and effectiveness may be obtained in the machine without passing the permissible limits of weight and bulk. Mr. Lart's discussion is directed primarily to the design and construction of British locomotives, but the principles apply, not only to all places but to many other machines besides the locomotive.—THE EDITOR.

THE production of steel of reliable quality and on a commercial scale undoubtedly rendered possible the instant and progressive development of railways and of locomotives as constructed today; it is, at the same time, equally true that the possibilities and demands of railways, and of the steam locomotive power on which their utility has always and, as the writer thinks, will always primarily depend, in spite of all possible development of electrical railway systems and the advantages claimed for this secondary form of tractive power, have directly called for and stimulated the rapid development of the several steel-making processes now in general commercial use, and the general reliability of the several classes of steel produced by them.

The progressive development of these steel-making processes has, however, proceeded on those cautious and essentially safe lines that inevitably mark the utility and practical value of all scientific and commercial matters.

But it may be interesting to enquire whether, in locomotive practice, the enterprise of locomotive engineers in the use of the various classes of steel suitable for locomotive construction has equally kept place with these developments.

The late Sir Henry Bessemer, in his autobiography, describing his own experience as pioneer of the manufacture and development of steel in Great Britain and throughout the world, has paid a well-deserved tribute to those British locomotive engineers whose practical recognition of the value of steel for purposes of their own particular industries did so much to assure the success of his own and all other subsequent processes of steel manufacture. Foremost amongst these, as he himself has stated, were the late John Ramsbottom, sometime locomotive superintendent and chief mechanical engineer of the London & North Western Railway, and his successor, the late Francis William Webb, under whom the writer had the privilege of studying at Crewe, and gaining his first practical experience of locomotive engineering.

The time seems to have come when locomotive engineers, having definitely laid aside all doubts as to the entire reliability of steel as made by any of the various processes now in successful commercial use, including the long-suspected basic steel, should turn their attention to the new possibilities now, though only compara-

tively recently, made available of using these alloys of iron, other than, or combined with, carbon forming steel which provide considerably enhanced strength, together with an equivalent saving in dimensions and weight—a combined ideal, which is the very thing that the necessary development of locomotive power requires.

Locomotives, up to the present, as with all other types of machinery and railway material, have invariably been constructed of what is known as "mild" steel, i. e., iron alloyed with a low percentage of carbon.

Such steel has a very appreciable advantage of possessing considerable elasticity as well as considerable strength, but the fact that the ratio of these two properties is essentially a low one, involves the defect in such steels that the proportions of any particular part of a machine, such as a locomotive, subject to high and usually continuous stresses, both calculable and unknown, has to be ample, and more than is theoretically necessary in relation to the work it has to perform, so that such parts are consequently excessively heavy in themselves, and produce in combination a machine of excessive and undesirable size and weight.

The writer has, at various times, touched upon this aspect of locomotive practice in reference to the remarkable and somewhat reckless development of British locomotives which has been witnessed in recent years; and there can be no dispute as to the feasibility of constructing locomotives of any possible power and size of the newer and much stronger steel alloys referred to, with a very considerable reduction in the proportions and weights in their individual parts.

Those familiar with the peculiar difficulties of British railway and locomotive construction should be the first to recognize these possibilities, and to make use of them.

But it seems that nothing yet has actually been done, at least on a really practical scale, to employ these stronger steels, and thereby to effect those all round economies in size and weight which are every day more and more insistently showing themselves to be necessary if British railway working is to progress in itself, and to prove even as commercially successful as in the past.

Both aspects of the question are important.

Mere progress, which is the natural outcome of all actual working conditions, is both useless and impossible unless it is accompanied either by distinct economics, or at least by no appreciably increased cost.

The figures available in regard to the cost of British locomotive and general railway working are, at the present moment, unsatisfactory in the extreme, and symptomatic of worse in the future.

Trades unionism, in its worst and now familiar and universal aspects, is accountable for much of the commercially unsatisfactory results referred to, and influences adversely every single item of British railway working.

While much may, and in the near future undoubtedly will, be done to mitigate this, there are many other methods immediately possible effecting detail and general economies which in themselves and in their general relationships will provide a recurrence of general prosperity in these matters.

Foremost amongst these are the possibilities of these new high-carbon, carbon-manganese, nickel, cobalt, chromium, and other steel alloys.

So far the locomotive engineers' ideal has been, for any particular purpose, a steel which will under no conceivable circumstances fail by fracture, though it may, and is calculated to, and does, bend or show other signs of failure before the actual breaking point is reached.

This is, in a way, all very well; but the amount of mischief that may be and usually is worked, and the resulting actual danger encountered by such preliminary failure of mild steel is only slightly less than what results

from actual fracture or destruction of any vital part of a locomotive.

It is, in fact, sometimes preferable that a connecting or coupling rod or an axle should break outright than that it should bend or become otherwise deformed, and effect wide spread damage on every other part of the engine. On the whole, speaking generally, a fracture outright would be preferable, as being likely to cause less general damage, and less actual danger to life, than a partial failure, which may not even be evident at the time, but will inevitably develop a worse condition in itself, and effect either partial or downright failure in the rest of the working parts.

Those who have seen in locomotive shops the results of such partial or complete failures would probably agree with the writer's contentions.

That the material used in locomotives should be thoroughly reliable is a primary axiom which needs no emphasis.

But reliability, as represented merely by elasticity and a disinclination of the part affected to break outright on the first over-strain, is perhaps too dearly purchased by the excessive weight which is, in mild steels, an inevitable accompaniment of such a quality, and in itself a direct inducement to, and cause of, both primary and complete failure.

The inertia of a reciprocating mass of steel, such as a piston-rod and its crosshead, or of a revolving mass, such as a crank axle or a tyre, or of a partly revolving and partly reciprocating mass, such as a connecting or coupling rod, produces strains that are only partially known, and can be only approximately estimated; such strains can, therefore, be only approximately provided for by scientific construction of the part concerned. Consequently such a part has to be designed of sufficient strength not only to deal with the known forces and stresses to which it is subjected, but also with a large margin of strength or factor of safety which together produce a mass of material excessive in itself and actually beyond the theoretical requirements of the case. This necessitates equivalent excessive weight and strength in accompanying individual parts, and therefore in the engine as a whole, there being what is practically a compound ratio of waste material, excessive weight, and increased dynamic strains both known and unknown. These represent excessive prime and maintenance costs in the engine itself, in the permanent way in which it runs, and also in the general economy of the railway system to which it belongs.

The reliability of mild steel, therefore, is a safeguard too dearly purchased from every point of view.

Now let us consider the case of ordinary "hard" steel, i. e., an iron-carbon alloy having a high percentage of the latter, as compared with the former element.

In such steels we have, proportionately to a mild steel structure of similar dimensions, design and weight, a considerably higher ultimate strength, i. e., breaking point, but a higher ratio of elasticity to such breaking strength. These characteristics have hitherto been assumed by engineers to be undesirable, as rendering the steel unreliable under stress, as compared with the "mild" steel.

But if we examine this proposition carefully, we may justly arrive at an opposite conclusion.

It is essential to the engineer that no part of his machine should fail at all, and he designs it as a whole, and proportions its various parts with this end in view; but he sacrifices lightness, and incurs considerable risk of failure throughout, notwithstanding.

It does not matter in practice, however it may appear in theory, whether the limit elasticity of any part is near to or far below the actual breaking stress. In a working part the former is all-important, for it is the critical point, beyond which any further stressing of the material is dangerous and impracticable. What objection, then, can there possibly be, either in theory or practice, that the

degree of preliminary failure or stress should approximate more closely to the point of final stress and actual failure than they are calculated to do in the "mild steels" at present universally employed in locomotive construction, and as they actually do in the "high carbon" or other high steels?

It may be said here at once, that there is nowadays no difficulty whatever in producing "hard" steels, whether of carbon or any other alloy, that are as absolutely reliable for every purpose of locomotive construction as—if not more than—mild steels, and possessed, weight for weight, of from 50 to 100 per cent. more strength. But just as "mild" steels, and basic steel in particular (which is admittedly more reliable in the "mild" than in the "hard" form), were for years regarded with universal suspicion, and therefore employed in forms of excessive weight and strength, as has already been pointed out, so, nowadays, engineers are equally suspicious of the general reliability of "hard" steel, and decline to recognize the possibilities of using such steels for obtaining, at a reduced size and weight, which may be from 20 to 50 per cent., an increased strength in any working part of at least equivalent ratio.

Given any such reliable "hard" steel of known high elasticity and breaking strength, as ascertained by the ordinary and quite reliable tensile and other tests, it should be the engineer's ideal to design every working part that can suitably be constructed of such steel—and in a locomotive almost all of its parts can be so constructed—with a view to the final breaking strength of the steel under the particular stresses to which he knows it will be subjected, leaving out of account altogether the problematical or even ascertained "limit of its elasticity," because such limit will, according and proportionately to the "hardness" of such steel, approximate very closely to the actual breaking-load, and quite sufficiently so for the difference to be amply covered by the necessary margin or factor of safety allowed for all material placed under working stress.

Now let us consider the case of a locomotive connecting-rod, which is subject to the most extreme stresses of any part of a locomotive, viz., a combination of alternate tensile and compressive strains, with direct bending strains, produced by the latter, and also indirect bending strains both in a vertical and lateral plane, and regularly intermittent, due to its own inertia of movement, and the inertia of every part directly connected to it —all such strains varying at each stroke of the piston, or twice per revolution of the driving wheels, from zero to maximum and back to zero, and at no moment constant in themselves.

The bending of such rods is a familiar and disagreeable feature of locomotive working, and has of late years become increasingly frequent, since the introduction of those excessively heavy passenger and goods locomotives now in almost universal use on British railways, of the so-called "Atlantic" and the six or eight wheels coupled types, in which the design necessitates the use of very long connecting rods, up to as much as 12 feet from centre to centre.

Such rods are always made of "mild" steel, i. e., with .30 to .36 percentage of carbon (the hardening elements of ordinary steels) and having a maximum tensile strength of from 28 to 35 tons per square inch, with a limit of elasticity of from 50 to 60 per cent. of these breaking strengths respectively.

To obtain the necssary strength in these rods to perform the work required of them, and to meet the complex strains referred to above, the rods require to be of far greater dimensions, strength and weight than would be required under similar conditions with rods made of "hard" steel, whether of high carbon or other alloy, having a maximum tensile strength of from 50 to 70 tons per square inch, with a limit of elasticity

of from 35 to 55 tons per square inch respectively. Such steel of absolutely reliable quality can be obtained, and be worked under the hammer as forgings, or be otherwise manipulated without difficulty.

As contrasted with this suggested use of hard and extremely strong forged or otherwise "worked" steel for locomotive parts, the possibility of replacing these by steel castings has long been recognized, and has been carried into practice in the case of such parts as are subject to simple stresses, as motion-plates, stays, axle-boxes, hornblocks and wheel centres.

The late Mr. F. W. Webb, of Crewe, referred to above, was the pioneer amongst locomotive engineers of such steel castings, and the somewhat bold use of this material in the locomotives designed by him, such as the cast steel balanced double cranks which he used on the low pressure axles of his 3 and 4 cylinder compounds, was amply justified by complete success and absence of failure, and has since been copied by others.

The writer also recollects some attempts being made at Crewe to cast steel connecting and coupling-rods, an idea which some engineers seem to have entertained for many years.

In this case success was not attained owing to the inefficiency of those immediately concerned in carrying out Mr. Webb's ideas, and not to any actual impracticability in them.

Mr. Webb's ideas were not often impracticable, in fact, but in this case he abandoned the making of these cast steel connecting and coupling-rods partly through pressure of more important objects, and partly because he knew the absolute reliability of the Crewe steel forgings.

But this question has never been actually abandoned amongst locomotive engineers, and recently the peculiar difficulties attending the production of sound and reliable castings of this particular difficult form seem to have been overcome by French engineers, whose locomotive practice, by the way, has always been sound and efficient, and has in recent years somewhat approximated to British methods.

Up to the present it has been taken for granted that only the very mildest qualities of steel are suitable for any sort of steel castings; and in the case of wheel centers, which present some difficulties on account of their peculiar form and the liability of the spokes to "draw" during cooling, such castings and all others subjected to heavy working stresses have been very carefully annealed after being "dressed" so as to relieve and regularize the initial molecular stresses set up by shrinkage during cooling from the molten to the solid state.

Steel castings, generally speaking, whether "mild or "hard," must be considered structurally unreliable as tending to lack homogeneity.

It has followed, therefore, that all steel castings have been made of dimensions and weights theoretically and even practically in excess of the strength required in them; here again, then, is one cause of the excessive weight of modern locomotives largely constructed of this generally useful material.

Nothing is gained, therefore, except, perhaps, some small cost of manufacture, in replacing forged steel connecting or coupling-rods by steel castings when made of the usual "mild" low-carbon quality; and up to the present no attempt has been made to employ the harder carbon steels for such purposes in locomotive construction.

But the practical researches of Hadfield, Windsor-Richards, Jr., and others ought to have convinced locomotive engineers that the hard manganese, nickel, cobalt, chromium, and other steel alloys suitable both for castings and forged or rolled material provide a range of ideal and reliable materials of wide diversity, of quality and especially suitability for the varied purposes of locomotive construction, and of toughness, strength and durability far in excess, size for size and weight for weight,

of the ordinary foundry and worked "carbon" steels.

One of the peculiar characteristics of some at least of these special steel alloys, whether cast or wrought, is the extreme toughness associated with their extreme hardness and deduced therefrom by water-quenching in the hot state or by ordinary annealing.

The utility of hard and high-tensile steel in parts subject to incessant and severe frictional wear, such as piston rods, tyres and axles needs no comment.

In the case of solid-forged crank axles, however, which are subject to direct torsional and varied twisting strains of great severity and complexity, the milder qualities of steel would undoubtedly be preferable as flexibility in such axles is requisite and the rigidity of hard steel inadmissible. But in the case of crank axles built up of separate parts such as those first applied to locomotives by the late Mr. Webb, of Crewe, the harder qualities of steel are quite the proper material; and so also for all straight axles which it has hitherto been the practice to construct of mild steel or wrought iron with case-hardened wearing surfaces.

The practice of making other wearing parts of locomotives, such as axle boxes, hornblocks and their adjustable wedge-bearing surfaces, of mild or wrought iron case hardened after machining is an expensive and unsatisfactory one in many ways, particularly as regards the inevitable "warping" of truly machined and finished surfaces in the hardening processes, and the necessity of readjusting these and finally truing up with the emery wheel. Such parts, in fact, cost nearly double as much as when made outright in hard steel, which costs no more in itself and very little more to machine, and wears quite as well as the merely surface-hardened mild steel.

Motion links, blocks and pins, reversing gears, eccentric rods, cotters gibs, wedges, and bolts and nuts, subject to constant wearing shocks, shearing strains, frequent adjustment under heavy hammers and keys, and other wear and tear, and spanners or keys also, and are obviously best made —though not usually so—of the harder qualities of steel.

Tires for all wheels, and driving wheels especially, cannot be too hard, as their slightly tapered rolling surfaces are quickly hollowed by the narrower rails on which they run, with the result that both wheels and rails are subjected to shocks, strains, and general wear and tear much in excess of those experienced when tires are newly turned and true.

It is found that all tires harden rapidly, simply owing to their constant rolling on the rails, and axle journals also, through rotating under their heavily loaded bearings, so that when these required to be trued up in the lathe, extremely hard cutting tools, or even emery wheels, are necessary to make a good job.

As regards boiler work, the somewhat high steam pressure of from 200 to 250 pounds per square inch, now extensively used in British locomotives, necessitates boilers of considerable strength; and as these are now of very large dimensions, their weight may amount to as much as 12 or even 15 tons empty.

Here again it has been the universal practice of locomotive engineers to use the mildest qualities of steel plates or the purest and most expensive brands of iron plates, the latter having some advantage as regards more elasticity and less tendency to corrode with, in consequence, a somewhat longer life.

Of late, however, a somewhat higher standard of tensile strength for boiler plates, has been instituted, so that in place of the maximum 30 tons per square inch breaking strength, from 35 to 40 tons are now considered permissible.

This is a move in the right direction, and enables a boiler of large size to be constructed of appreciably thinner plates and reduced weight

quite capable of being worked at the highest pressures and as durable as a similar but necessarily heavier boiler constructed of thicker mild steel plates.

The following details may be taken to represent the average physical characteristics of such high-tension steel plates, as actually ascertained by the writer from a carefully conducted series of tests:—

ANALYSIS	Per Cent.
Carbon	.34
Manganese	.87
Silicon	.04
Sulphur	.06
Phosphorus	.055
	1.366
Iron by difference	98.634
Total	100.000

TENSILE TEST

Breaking load, 36.7 tons per sq. in.
Elastic limit, 20.4 tons per sq. in., 55.5 per cent. of breaking load.
Elongation on 8-in. test length. 22 per cent.
Reduction of area 37.4 per cent.

By the universal use of the hardest qualities of steel suitable for the various purposes enumerated above, combined with the proper amount of toughness—two qualities quite consistent with each other and characteristic of most of the new hard high-tensile steels, as has been already pointed out—both prime cost of manufacture and cost of maintenance and repair may be secured in locomotive construction and working, together with an increased utility and life—qualities which must obviously effect considerable economies in locomotive construction and operation.

AUTOGENOUS WELDING

By F. C. Cutler

The old idea of welding metals was confined to the work of the blacksmith shop, this including its extension to the great forges in which the steam hammer and the forging press enable work to be executed on an immense scale and with a rapidity impossible with manual effort alone. In such methods, however, there is a great waste of heat and of energy, especially when intricate and difficult operations are to be performed, and there has long been a demand for some method by means of which a high temperature could be produced upon a very limited area, under such control as to permit special forms of welding to be practically accomplished. For some such purposes electric welding has been effectively applied, but this ingenious system has not had as wide applications as were at first anticipated. The oxy-hydrogen blow-pipe has been used with some success, but the latest apparatus to be given commercial application for welding is the oxy-acetylene blow-pipe. The ready production of acetylene, together with the development of modern economical methods of generating oxygen, have rendered this system most effective, and the following account of its practical operation will be found of much interest.—The Editor.

THE development of processes for cold forging and drawing, especially for the manufacture of pressed-steel parts for automobiles, bicycles, and other high-class machine parts, has shown the necessity for some effective and reliable system of welding such parts together. Ordinary brazing does not fill this demand, since it is evident that the machine parts produced from the highest grade of steel, in the press, would lose nearly all of their value if they were united by any process having a lower strength and quality at the joint than in the body of the metal itself. Obviously the only method which could be acceptable for such work is some system of welding, in which the metal itself is structurally united in such a manner that the finished product forms one homogeneous piece, of uniform quality and properties throughout.

This demand means that the metal must be welded at a temperature high enough to cause it to be its own joining material, and hence the term "autogenous" welding has been given to the process in which the parts are fused together by their own substance.

Since such work requires but a small area to be raised to the high welding temperature, it is evident that some form of blowpipe is adapted for this purpose, and in practice the work is done with the oxy-acetylene blowpipe, the combustion of acetylene in the presence of oxygen giving an intense heat in a controllable area.

Theoretically there are required $2\frac{1}{2}$ volumes of oxygen for the complete combustion of one volume of acetylene. Practically, however, with the oxy-acetylene blowpipe the best welding results are obtained with 1.7 volumes of oxygen to one volume of acetylene. The acetylene, therefore, is not completely burned in the blowpipe, according to the reaction:

$$\underset{4\text{ vol.}}{2\,C_2H_2} + \underset{10\text{ vol.}}{5O} = 4\,CO_2 + 2\,H_2O \qquad (1)$$

But is incompletely burned, according to the reaction:

$$\underset{2\text{ vol.}}{C_2H_2} + \underset{2\text{ vol.}}{O_2} = 2\,CO + H_2 \qquad (2)$$

This is understood when we consider that at the intense heat produced by this combustion, the water and carbon dioxide formed by the reaction (1) are completely dissociated. To this last fact is chiefly due the success of the oxy-acetylene flame as a welding agent. To establish the proper conditions for autogenously welding two metals, it is necessary to bring them to their melting point without oxidizing or carbureting. As shown by the formula, this flame consists largely of carbon monoxide, which is being converted at its extremity into carbon dioxide. This, with the hydrogen, forms a relatively

THE OXY-ACETYLENE BLOWPIPE

cool jacket, which protects the molten metal and the inner cone from the loss of heat.

Of the two gases used in the oxy-acetylene blowpipe, the acetylene is readily produced, since calcium carbide has been on the market.

Acetylene ($C_2 H_2$) is a hydrocarbon colorless gas, of an ethereal odour when perfectly pure, but, as ordinarily obtained, is distinctly offensive to the smell. It is also an endothermic, or heat absorbing gas, nearly as heavy as air, its density being 0.92 compared with air.

When calcium carbide (CaC_2) is brought into contact with water, there is produced acetylene gas, according to the reaction:

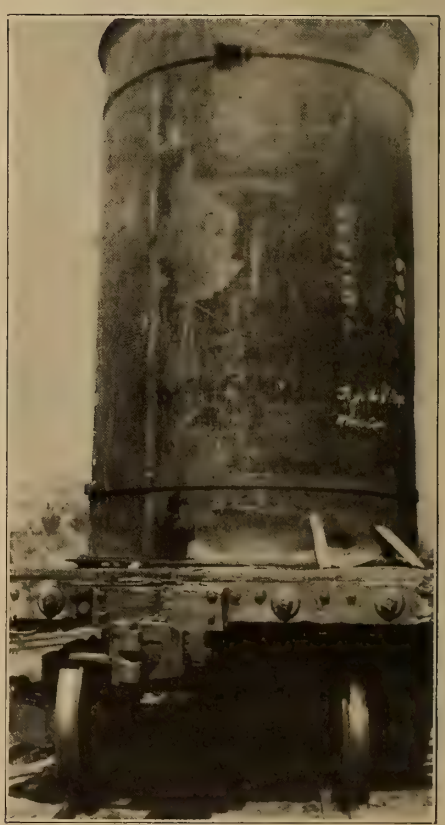
$$Ca\,C_2 + 2\,H_2O = C_2H_2 + Ca\,(OH)_2$$

As acetylene is rich in carbon, containing 92.3 per cent., it is possible to obtain, by its combustion with air in a Bunsen burner, a temperature nearly as high as that of the oxy-hydrogen blowpipe flame, or 3,600 degrees F. When acetylene is burned with oxygen, however, there is produced the hottest flame known as a product of combustion, the temperature reaching 6,300 degrees F., or nearly the temperature of the electric arc.

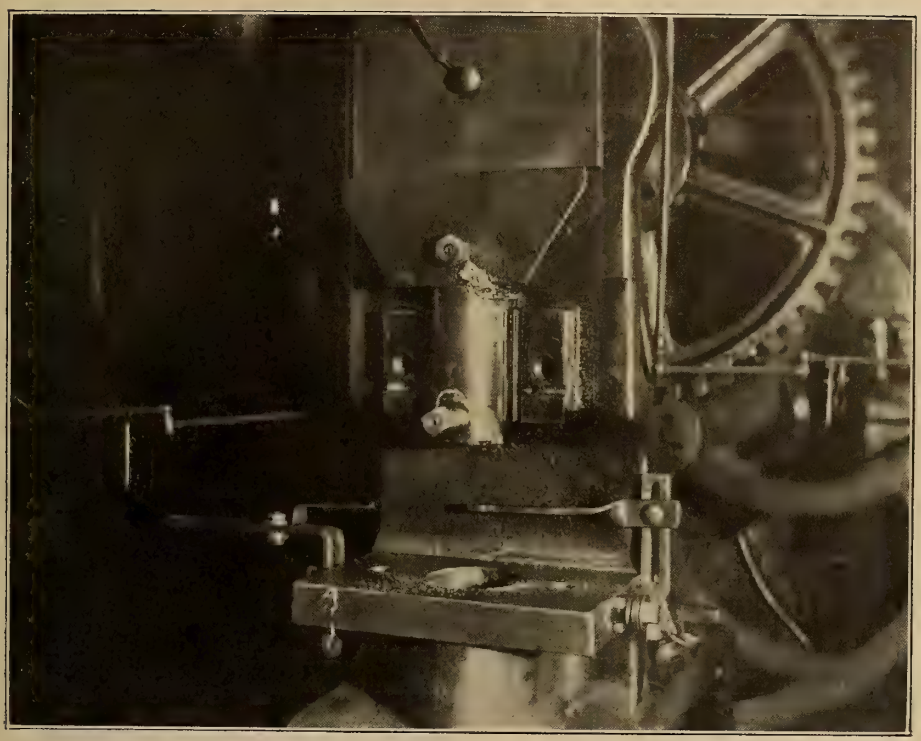
The production of the oxygen necessary for use in the oxy-acetylene blowpipe is an important element in the commercial success of the process, and until methods for providing oxygen commercially had been devised, the oxy-acetylene blowpipe necessarily remained in limited application.

An interesting and commercially successful method of generating oxygen for blowpipe use is that employed by the Worcester Pressed Steel Company.

This process employs the combination of a calcium compound with copper sulphate and with sulphate of iron. The oxygen-generating apparatus consists of two lead-lined chambers, arranged with a scrubber and settling chamber between. In making oxygen, one generator is filled with the required amount of lukewarm



STEEL TANK 10 FEET BY 5 FEET, WITH WELDED SEAMS



CAST-IRON POWER PRESS; RAM REPAIRED BY WELDING WITH THE OXY-ACETYLENE BLOWPIPE

water to which one chemical charge is added. While this solution is being stirred with an agitator operated by a crank provided for the purpose, a solution of iron sulphate and water is added, which acts as a catalyzer. The chemical reaction is represented as follows:

$$6\,Fe_2SO_4 + 7\,Ca\,O\,Cl_2\,Aq + Cu\,SO_4\,Aq = 2\,Fe_2(SO_4)_3\,Aq + Cu\,SO_4\,Aq + Fe_2Cl_6 + 7\,Ca\,Cl_2 + 3\,Ca\,SO_4 + 7O$$

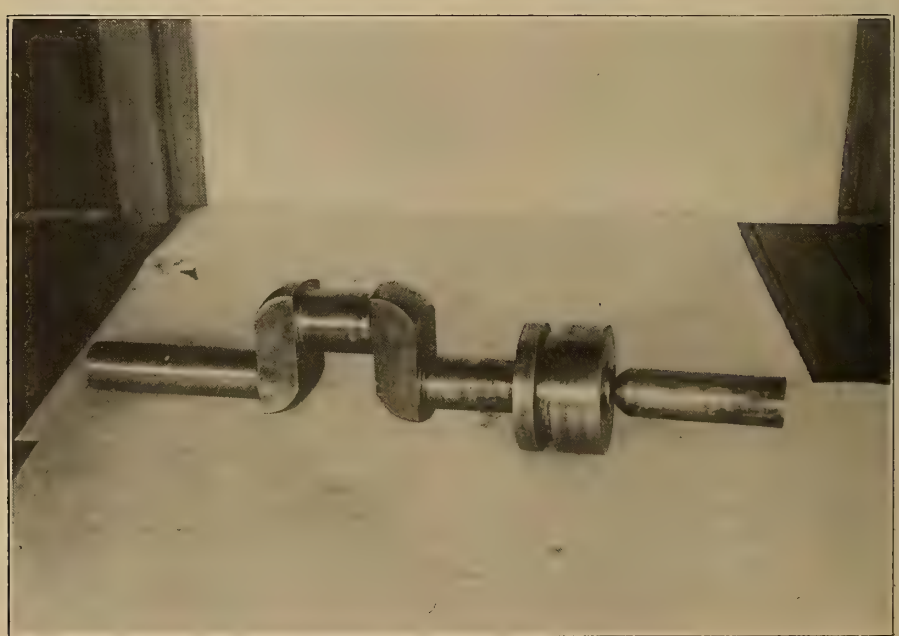
and the liberated oxygen passes from the generator through the scrubber and a water-sealed trap into the gasometer. From the gasometer the oxygen is compressed by an ordinary air compressor to a pressure of 10 atmospheres, or 147 pounds per square inch, into a pressure storage tank, from which a system of copper piping enables the gas under pressure to be delivered to any part of the works. The main piping is of copper $\frac{3}{8}$ inch in diameter, from which branches of $\frac{1}{4}$ inch copper pipe lead to the blowpipe connections. Suitable reducing valves enable the pressure to be regulated at will, and each blowpipe is provided with a number of nozzles of different sizes, to adapt the flame to the character of the work.

The acetylene generator used by the Worcester Company is of the water-feed type, composed of a cylindrical tank which serves as a gasometer and regulator, connected by three water-supply pipes to three carbide receptacles or trays, semi-cylindrical in shape, each containing six compartments, each tray holding about 12 pounds of lump carbide. The acetylene is used under practically a uniform pressure, ranging from 2.2 to 3 pounds. The pressure is obtained and maintained by two water levels in the gasometer, employing as a means the principle of the well-known water column, which automat-

A BROKEN SHAFT FORGING

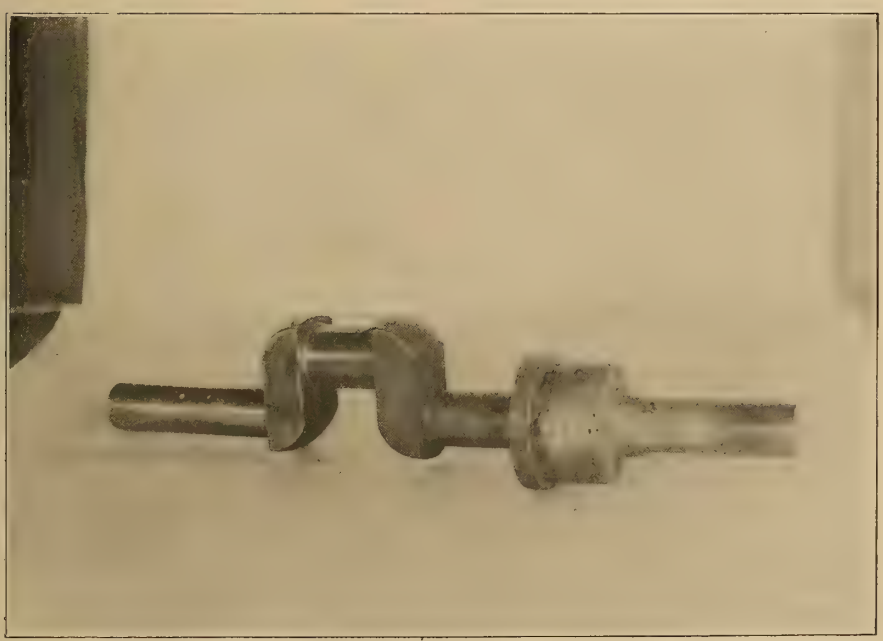
ically governs the supply and pressure of the gas. Any pressure in excess of 3 pounds escapes through a vent of blow-off outside of the generator building. The gas is led from the generator through a main 1 inch in diameter, with branches of $\frac{3}{8}$ inch in diameter leading to the blowpipes.

The blowpipe is of brass construction, especially designed upon the in-

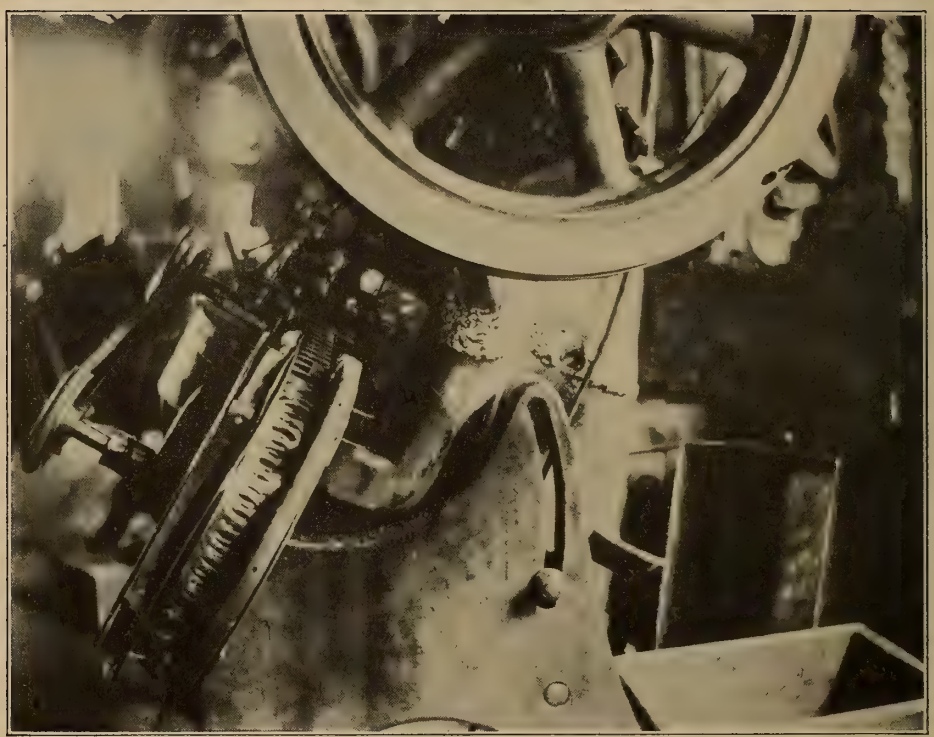


THE BROKEN SHAFT READY FOR WELDING

WELDING THE BROKEN CRANK SHAFT



THE WELDED CRANK SHAFT



CAST-IRON FRAME OF POWER PRESS REPAIRED BY THE OXY-ACETYLENE BLOWPIPE

jector principle, carefully proportioned for its purpose, being about 24 inches in length and weighing 2 pounds. It is provided with two inlets which remain practically separate the entire length of the instrument, and enter a mixing chamber with a common outlet at the point of combustion. In lighting the blowpipe the acetylene is first turned on full; then the oxygen is added until the flame has only a single cone. At the apex of this cone there is a temperature of 6,300 degrees F., and in welding, this point of the flame is held from $\frac{1}{8}$ to $\frac{1}{4}$ inch distant from the metal to be welded. Too much acetylene produces two cones and a white color, while an excess of oxygen causes the flame to assume a violet tint.

At the moment of initial combustion, when the acetylene is decomposed into its elements of carbon and hydogen, there are evolved about 300 B.T.U. per cubic feet of gas. The total heat, however, generated per cubic foot of acetylene is about 1,500 B.T.U., which, aside from the initial decomposition, is furnished mainly by the combustion of the carbon in oxygen to carbon dioxide, and in a lesser degree by the combustion of the hydrogen into vapour of water.

Pure acetylene, at a pressure of less than 30 pounds, is perfectly safe, even when passed through pipes at a white heat, but when mixed with air or with oxygen it is dangerous. An explosive gas mixture enclosed in a pipe does not inflame at once throughout the entire length, but the ignition travels from one end of the pipe at a speed which increases as the square of the pipe section. In order, therefore, to render the use of oxygen and acetylene safe in the blowpipe, the gas mixture is given, by pressure, a speed greater than the rate of propagation of the flame.

In the autogenous welding of metals such as iron, steel or copper, no flux or moulds are used, but for al-

loys such as brass or bronze, a little borax or boracic acid, moistened with water, is applied, simply to prevent the volatilized zinc from being deposited on the joint and destroying the weld. The process is wholly one of fusion, forming a perfect metallic union of the parts, the joint being imperceptible after finishing.

Autogenous welding is used in place of riveting or soldering, and permits many forms of construction not otherwise possible. Two sheets of metal may be welded simply by placing their edges in contact and following along the seam with the blowpipe. Tanks of almost any shape may be made by forming the body and ends separately, and then, in assembling, tracing the flush and butt joints of the seams by the blowpipe. To insure strength, the joint may be slightly overloaded, by melting a wire or rod of the same material at the same time that the edges are fused. This makes the unfinished joint stronger than the body of the metal, while the finished joint is practically the same as any other part of the sheet.

Any shaped hole can easily be cut in a steel plate up to 6 inches in thickness, and with the blowpipe the operator can accomplish cutting feats impossible with the saw. In cutting, the flame is proportionately elongated by pressure to penetrate to the bottom of the cut. The intense heat is so localized that the kerf is practically the same as if a saw were used.

Not only is the process adapted for making tanks, boilers, tubing, cylinders, pipe-joints and angles, and for replacing brazing and riveting in many instances, but it can be used effectively to weld cast iron. In the foundry the method enables many defective castings of iron, steel, brass, etc., to be saved, since the blowholes can readily be filled and broken castings welded as strongly as new. In repair work it is especially valuable, and many expensive castings, forgings, and machined parts may be saved from the junk pile by an hour's use of the blowpipe.

STEEL TUBES WELDED INTO SHELL

The cost of the process may be indicated by the following figures, deduced from actual practice, and giving the time and cost for gas for welding sheets of steel or copper, by a workman of average ability.

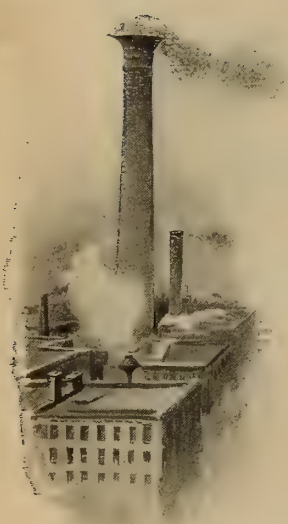
Thickness of Metal, Inches	Speed, Inches Per Hour	Cost Per Inch
0.035 (about 1/32)	288	$0.0031
0.062 (about 1/16)	200	0.0065
0.125 (about 1/8)	120	0.016
0.377 (about 3/8)	60	0.075

Metal of $\frac{1}{4}$ inch and less in thickness can ordinarily be welded cheaper than riveted. Steel and copper tanks for high and low pressure of almost any dimensions are effectively welded in place of riveting; broken steel shafts or other forgings repaired; cast iron welded with copper or steel, and blowholes and similar defects in castings and forgings made good.

Some difficult autogenous welding has been accomplished with aluminum, practically overcoming the trouble from the oxide which forms on the surface of the aluminum when exposed to the atmosphere. Although aluminum has a comparatively low fusing point, about 1,200 degrees F., it conducts and absorbs heat rapidly, and requires a comparatively high local heat to obtain the best results.

BOILER-ROOM DESIGN AND EQUIPMENT

By Wm. H. Bryan, M. Am. Soc. M. E.



WHATEVER of development the future may hold for the water wheel and the gas engine, the steam power plant—like unto the poor—we may expect to have it ever with us. Over such wide areas is its influence felt, and of such gigantic proportions are its advancement and usefulness, that it is distinctly worthy of our homage. We are not likely very soon to see it vanish from the earth.

It is not our present duty, however, to discuss the modern power plant as a whole. As an energy-converting agency, its part in the economics of modern industrial life is secure. Nor are we concerned in its location—whether near the centre of service, or at distant but favourable points, where fuel is cheap, and light and air and ground space are abundant.

Engineers may well differ as to the particular feature of the modern power plant which outranks the others in importance—if, indeed, any one of them may be said to do so. To the disciple of Watt and of Corliss there is a never failing inspiration in the steam engine. Of such varied type and structure are they to-day, and of such great capacity—so admirably are they adapted to their severe and arduous duties, that their rank must always be high.

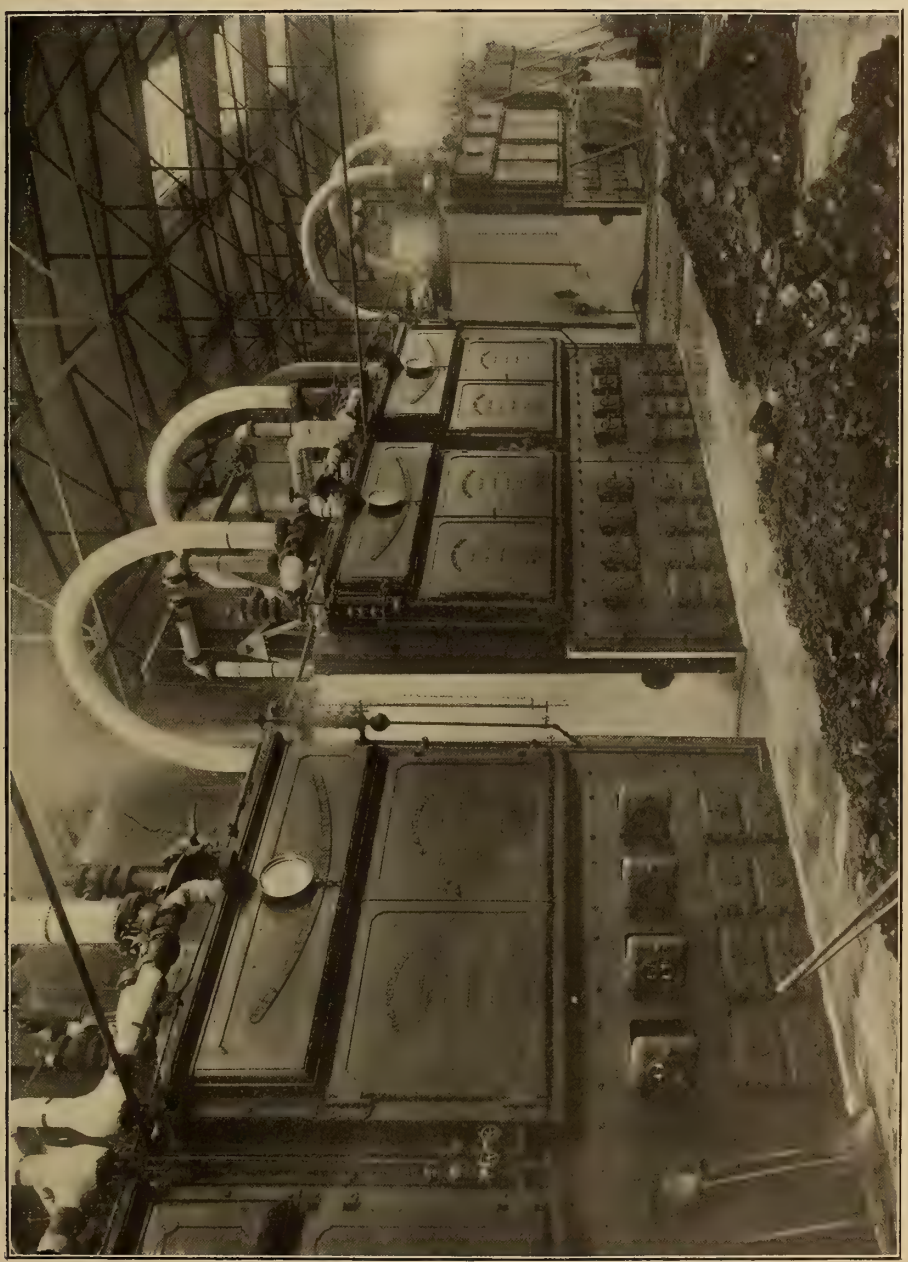
To another the generators appeal—and well they may—for in them are the life and passion, the energy—which does things. We shall always admire and stand in awe of them.

Another specialist pins his faith to the switchboard, that nerve centre, that dispatching station, that clearing house, if you will, which gathers and measures, controls and safeguards, and sends forth upon its various missions, the subtle fluid of which man so recently became the master. To him all honour, for he who knows the intricacies and the potentialities of the modern switchboard, is surely of the elect.

To still another there is a fascination in what we may term the minor features of the station—the building which houses it, the foundations, the pipe work, the condensers, the water supply, the feed pumps, and all the various what-nots of an intricate plant. Each of these has its duty—not one of them can be spared or slighted. Of each many a thrilling story has been written, and so long as power plants persist, they will be worthy of—and continue to receive—our earnest study.

For the moment, however, let us pass all of these by—for our present business concerns the boiler room.

We shall have goodly company, but we shall not be crowded, for the attractions of the average boiler room do not appeal to the ordinary mortal. No tiled floors and marble wainscoting are here—no nickel-plated fittings, no glistening rods, no bright and tasteful uniforms, but for the most part—let us admit it in shame—dirt and darkness, dust and heat, perspiring men, and stifling and noisy surroundings. It is a place to hurry



BOILER ROOM OF THE CHAMPION COATED PAPER CO., HAMILTON, OHIO, SHOWING HEINE WATER-TUBE BOILERS, FITTED WITH HAWLEY DOWN-DRAFT FURNACES. NOTE THE AMPLE HEAD ROOM AND FREEDOM OF ACCESS TO ALL PARTS

BOILER ROOM OF COMMONWEALTH ELECTRIC CO., CHICAGO, BABCOCK & WILCOX BOILERS EQUIPPED WITH CHAIN GRATES AND SUPERHEATERS. A CHARACTERISTIC MODERN BOILER ROOM

through—to forget. Even the attendants shun it. What wonder then, that as the coal pile dwindles, and the gaping wound in the master's strong box widens, he is sometimes surprised that his crop of kilowatt-hours is relatively so meagre?

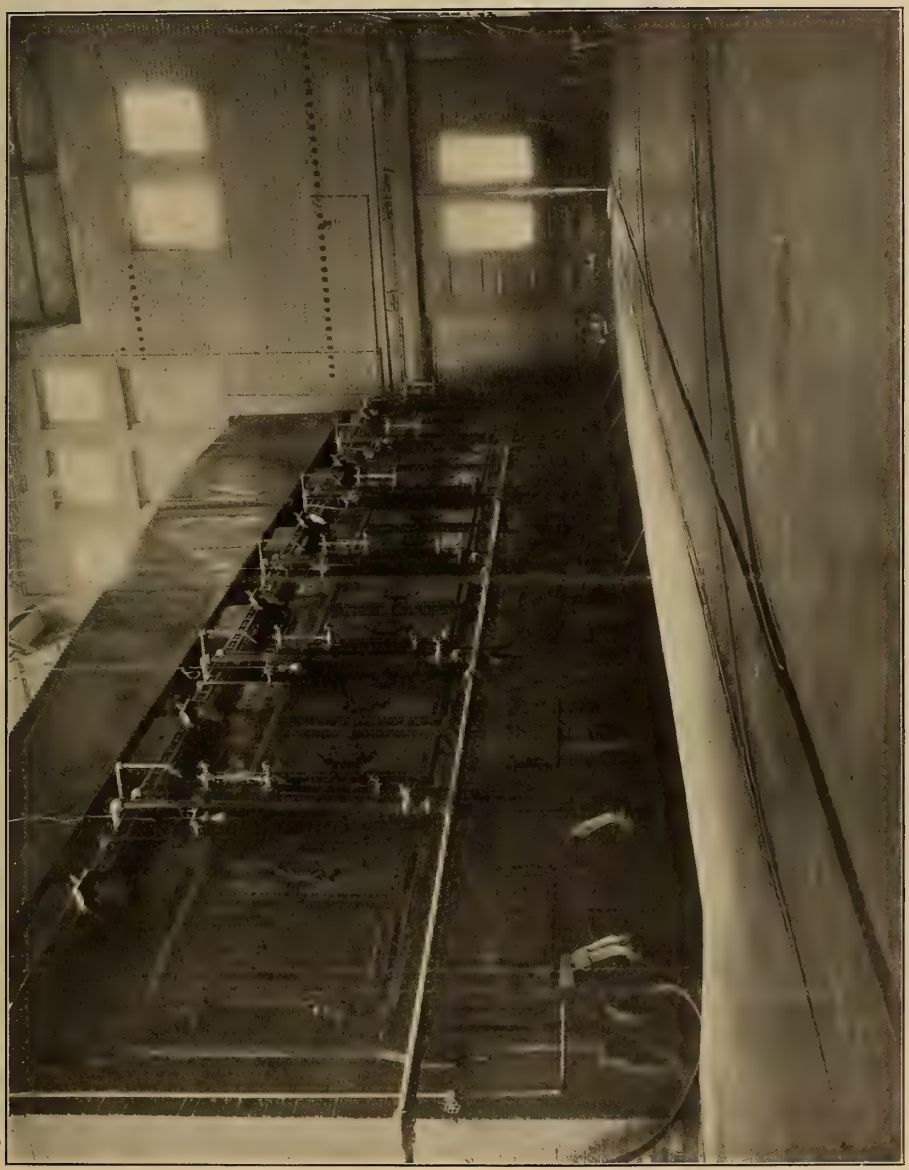
This is a common enough picture—but there are numerous and notable exceptions—and it is cause for congratulation that the better planned boiler rooms grow constantly more numerous. All hail, then, to the modern boiler house, where order reigns, where light and fresh air and cleanliness and room abound—where existence is not a curse—and where the master has the same pride, and is as ready—yea, anxious—to take his friends, as among the glistening beauties of the engine room. Here each pound of coal gives a good account of itself, and kilowatt hours are worth the saving. Here is where our interest lies—not in the boiler plant of the average station, but in the well and thoroughly planned boiler house of modern times.

What are the controlling ideas which should govern boiler house design? What is the present trend of the best practice? To what extent may it be said that we are approaching—and to some extent realizing—lines of design which may be called standard?

To the answering of these questions we may address ourselves with strong hearts and in good faith—for granting all that may be hoped for in hydro-electrics, and in gas producer and gas engine development, there will yet be many a boiler plant to build.

There is wisdom often in the marshalling for review of our forces ere the real attack begins. Briefly, then, what are the elements of our problem?

1st. The boiler itself—the pressure



A MODERN STEAM PLANT, WITH BOILERS BY THE BIGELOW CO. C. W HUNT CO., INDUSTRIAL RAILWAY AND FLOOR

to be carried, its type, capacity, number and size of units.

2d. Its setting and auxiliaries, such as grates, stokers, furnaces, smoke flue, draft appliances, and chimney.

3d. The fuel—its quality, the best appliances for its combustion, its storage and handling—the disposal of ashes.

4th. Auxiliary appliances such as superheaters, economizers, air-heaters, boiler feeders, etc.

How may the various constituent units of the boiler plant be placed with reference to each other and to the plant as a whole, to secure the high-set efficiency?

Taking up these in order, let us first discuss

THE BOILER.

What working steam pressure should it be designed for—what type best meets modern needs—how many units should there be, and what should be their capacity?

As to pressures, modern engine design has seemingly settled on about 175 pounds above atmosphere—though there is a tendency in some quarters to increase this to about 200. Plants of moderate size continue to be designed for 125 to 150 pounds.

Considering design, the conditions to be met are: strength, safety, minimum space occupied, quick steaming, no entrainment, ability to overwork continuously at the "peak" of the load and in emergencies, ability to withstand hard service, simplicity and reliability. All these are admirably met in the modern water tube boiler, of which many excellent types are on the market.

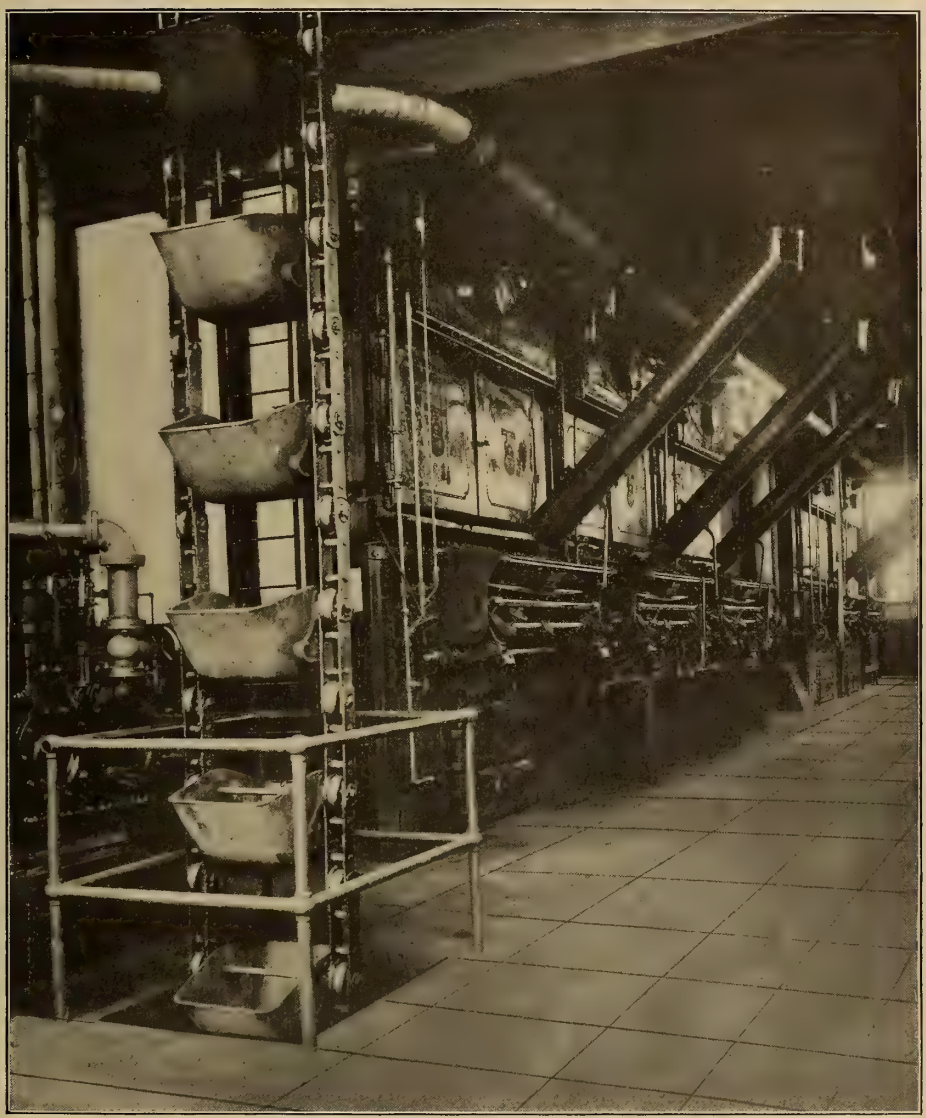
The number of boiler units to be installed depends upon many things. A convenient and popular plan is to have a boiler—or group of boilers—for each power-generating unit, engine or turbine. This boiler unit, as a rule, serves its own generator by direct pipe lines, but is cross connected by steam headers so that it may serve other units as well.

Engine capacities in single units have advanced far beyond those of the boiler—for reasons not far to seek. We now have engines of 10,000 indicated horse-power rated capacity, and steam turbines still larger. The largest single boilers now built rate at about 1,000 boiler horse-power, and even these are usually special. There is beginning to be a demand for still larger sizes, which the makers will no doubt find ways to meet. It is not uncommon in such cases to set two boilers in a single furnace.

And even this tells but half the story. The modern steam engine consumes but 15 pounds of steam, or less, per hour for each horse-power which the indicator shows it to be developing—while the unit of boiler horse-power is, in round numbers, 30 pounds of water evaporated into dry steam per hour. A single boiler of 1,000 horse-power rated capacity, is able therefore to serve an engine rated at 2,000 horse-power, so that a group of five will be necessary for a single 10,000 horse-power engine.

The total boiler capacity depends, of course, upon the size of the plant—its rated and maximum capacities. Given these, a plan which has much to commend it, when the situation permits, is to divide the total into not over five, and not less than three boilers or groups of boilers. This prevents a multiplicity of small units, and on the other hand avoids the use of unnecessarily large units.

We must not lose sight of a condition characteristic of all electric power plants—the wide fluctuation of demand to which they are subject, and to which they must promptly and satisfactorily respond. Modern steam boilers, and engines as well, are designed to carry regularly and continuously 25 per cent. beyond their normal ratings, and for short periods one-third and even 50 per cent. greater. Under such conditions efficiency is for the moment lost sight of—the essential idea being to "get results." Nor is this bad engineering. The extreme "peak" is usually



BABCOCK & WILCOX BOILERS WITH RONEY MECHANICAL STOKERS, AND HUNT COAL AND ASH CONVEYOR IN FOREGROUND; CONCRETE FLOOR

limited to a few hours' duration during the late afternoons of two or three winter months. It is entirely legitimate to plan for the regular and reasonable use of this overload characteristic rather than increase the fixed charges on the plant, already high, by such additions to the capital account as would be necessary for the installation of capacity sufficient at rating to take care of the maximum loads.

While it is legitimate, therefore, to overload the units as explained, it is equally imperative that at the "peak" there still be one unit, or group, in reserve, ready to take the place of any unit disabled or temporarily out of service for cleaning or repairs.

THE SETTING.

In plants of magnitude where coal is burned, it has become standard to install some form of automatic stoker.

A number of these have now been perfected and will render excellent service—even with inferior coals and under forced conditions. Included under this designation are the underfeed devices and chain grates. Great care must be exercised in the selection of a stoker, for the reason that much depends on the coal to be used; its percentage of volatile matter, ash, sulphur, and its caloric value. Also as to the sizes in which it is usually obtainable, and whether it is often received wet, or characteristically runs high in moisture. Simplicity, reliability and readiness to stand up under severe overloads and with inferior fuels, are the characteristics most desirable. One of the incidental advantages of a good stoker is smokeless combustion, an important consideration everywhere, and particularly in cities. Not only is this requirement in line with good sanitary and æsthetic ideas, but it is good economy, for, as a rule, a smoky chimney indicates wasteful furnace-conditions.

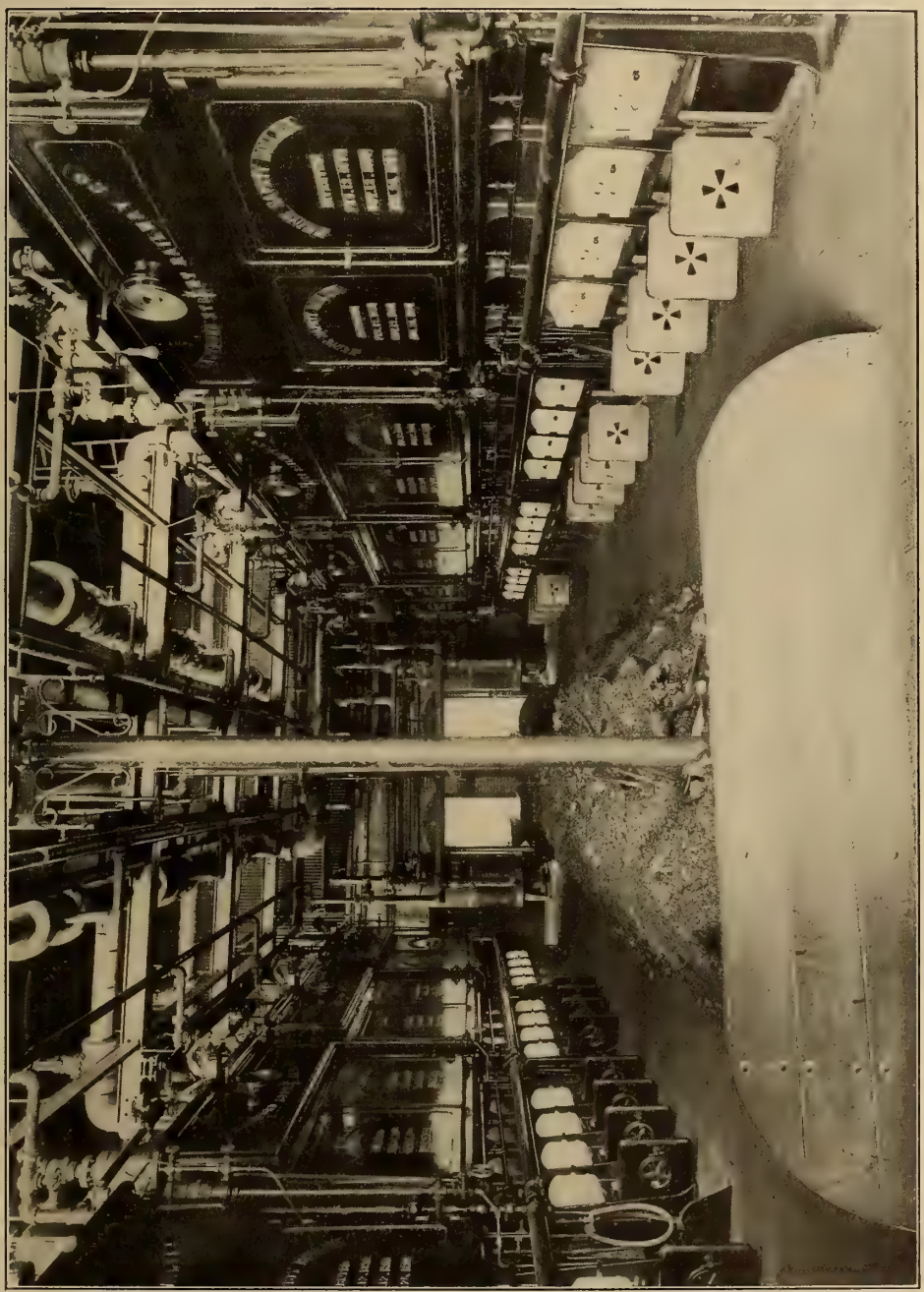
As to the furnace itself—that is, the masonry enclosure—the foundations must be such as to make settling or cracking of the walls impossible. The gas passages, sometimes called calorimeter areas, should bear a fixed and predetermined ratio to the heating and grate surface—this again depending on the character of the fuel. The designer should always bear clearly in mind the fact that it is the draft in the fire box which burns the fuel. However excellent the draft may be at the base of the chimney, it is worthless if dissipated between that point and the bed of fire by short bends, cramped gas areas, soot-filled flues, economizers, or other obstructions. The walls should have dead air spaces, say two inches in width, and care should be taken to avoid air leakages into the furnace. Some go so far as to place the walls within a sheet iron casing. This is a detail deserving of more attention than it usually receives. It is often good policy to face the walls with high grade brick, either white enameled or pressed gray.

Damper regulators, by which the damper is automatically opened and closed, as the steam pressure tends to fall or rise, have been widely adopted, and are most excellent devices, as a rule. They may be had in much variety, and of durable and reliable make. Where mechanical draft is installed, governors may be arranged to control the speed of the fan, with equally efficient results.

The smoke flue should be ample in area, preferably circular in cross section, with as much rise towards the chimney as can conveniently be given it, as direct as possible, and provided with bends of large radius. Its area should be proportioned to the last boiler passage, bearing in mind two facts: first, that the area can safely be cut down as the gases cool, and second, that a horizontal flue should be a little larger than a vertical one for the same service. Ample provision must, of course, be made for cleaning and repairs.

For many classes of service, particularly where economizers or superheaters are employed, and where it is necessary to force the plant to extreme at times, or where it is desirable to burn low grades of fuel, mechanical draft is advantageous. By the help of this apparatus, a boiler with banked fires may, in emergencies, be gotten into service at perhaps double its rating in a very few minutes. With such apparatus a high chimney is unnecessary. Serious mistakes have been made in this field by putting in fans too small, with the result that it was found necessary to run them at such high speeds as to make their performance unsatisfactory. When the increased draft is required only for short periods, as at the "peak" of the load, or in emergencies, a plain steam jet with suitable nozzle can be made to answer. Its first cost is very low, as is also its efficiency.

Even under such conditions, however, many authorities still prefer the



BOILER ROOM OF HARTFORD STREET RAILWAY COMPANY, HARTFORD, CONN. HEINE WATER-TUBE BOILERS. NOTE THE ARRANGEMENT OF STEAM MAINS AND CONNECTIONS

tall chimney. Particularly is this the case where large plants are built in or near the thickly settled portions of large cities. Not infrequently both high chimneys and mechanical draft are installed. For this service the old-time brick stack has been largely superseded by the steel chimney, self-supporting and lined with fire brick, the radial-tile stack, and more recently the reinforced concrete chimney.

THE FUEL.

Something has already been said of this feature, but no point is more deserving of exhaustive study. Not only is its quality important, as has already been pointed out, but the supply must be regular and reliable and its price right. Most plants very properly aim to burn the cheaper grades, such as slack or pea, which are now often to be had washed, but crushers should be installed at proper locations for use in case only the large sizes are temporarily available.

Hardly less important is it to be able to receive, handle, and feed the fuel to the furnaces cheaply and quickly. Overhead storage bins, often of the W type, to feed opposite rows of furnaces, are often installed. Their capacity should be as large as possible—holding at least 30 days' supply. Elevating, conveying, dumping, and chute mechanism, with travelling and weighing hoppers, should be installed, capable also of caring for the ashes, for which special bins should be provided, holding a car load or more. In the design of coal and ash handling and storage plants, consideration must be given to the value of the space, as well as the cost, and other objectionable features of overhead storage.

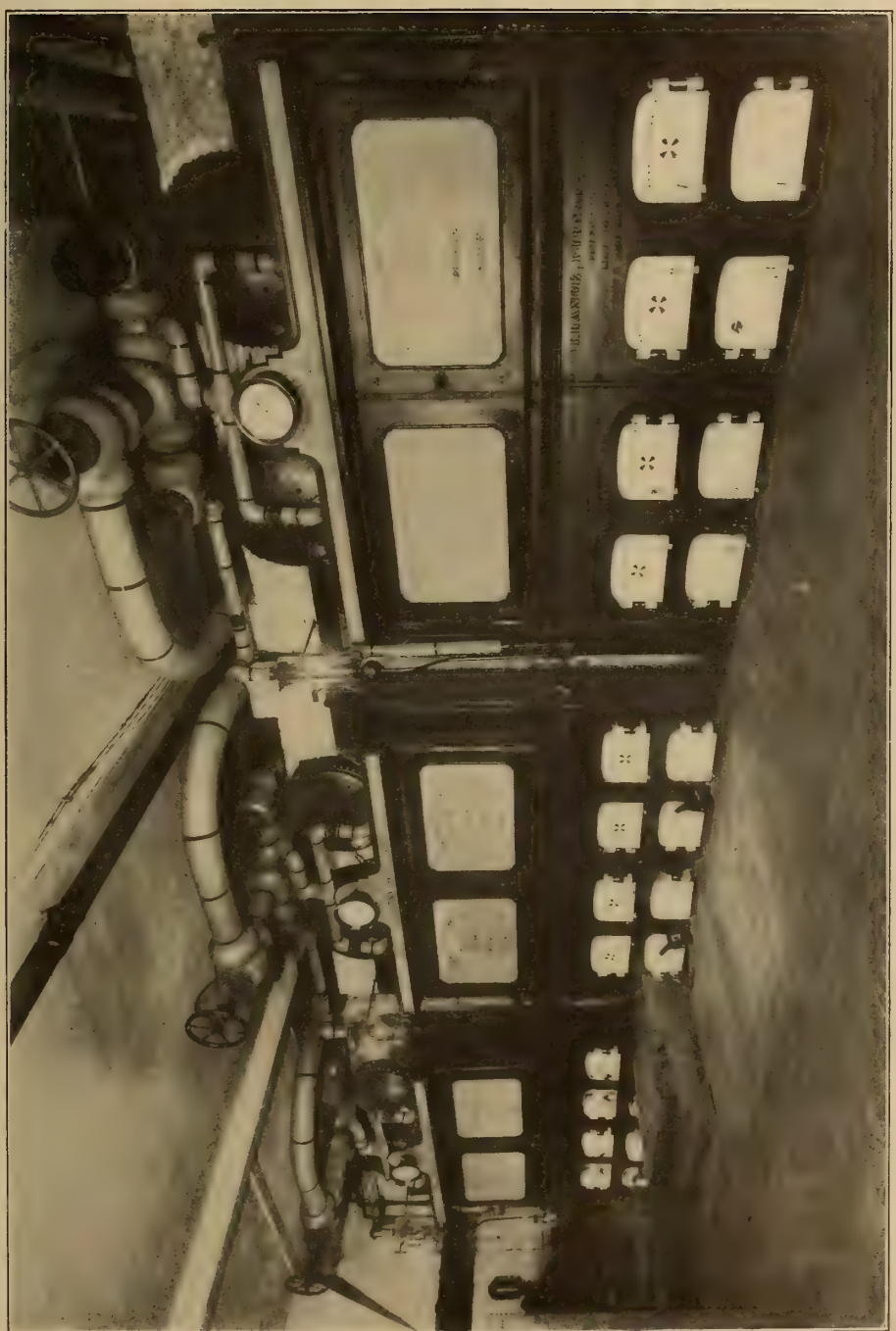
Coal must not be left in storage too long, nor exposed to the weather, as it is subject to deterioration. Furthermore it is liable to spontaneous combustion, particularly the smaller sizes. Some recent experiments with storage under water have given excellent results.

Approved apparatus for determining the calorific value of the fuel burned, and for indicating, and if possible recording, the composition of the escaping chimney gases, should be supplied. Calorimeters for the former purpose, and econometers, CO_2 recorders, etc., for the latter, are now available, of excellent design, reliable and simple in construction. Fuels vary continually in quality, even from the same district, and not infrequently from the same mine. There is no better check on the fuel contractor than frequent calorific determinations. In many cases it has become the practice to purchase fuel upon a heat-unit basis, a plan which has much to commend it. In the case of large installations it will pay to go even further, making frequent proximate and occasional ultimate analysis of samples of the fuel, so as to keep track of all its constituents, particularly the moisture, ash and sulphur.

Not less important is it to see that the fuel is properly burned, that the combustion is as nearly complete as good apparatus and intelligent handling can make it. All this can readily and surely be controlled by modern instruments. When the showing is not right, prompt and effective remedies may be applied.

AUXILIARIES.

The development of the modern superheater, and its seemingly well founded claims of efficiency, have led to its use in many high grade plants. Sometimes it is separately fired, but more often it forms a part of the boiler proper. Authorities differ as to the amount of superheat desirable, ranging all the way from 50 to 200 degrees Fahrenheit. Some measure of agreement, however, is found at such superheating as will carry the steam into the condenser dry, but without superheat. This appears to be about 150 degrees. The installation of a superheater should not, of course, relieve the boiler from the necessity of supplying dry steam.



BOILER ROOM OF THE GREAT NORTHERN HOTEL, CHICAGO, SHOWING INSTALLATION OF HEINE WATER-TUBE BOILERS AND PIPING ARRANGEMENT IN RESTRICTED HEAD ROOM

Economizers, to get from the waste gases into the feed water the last possible unit of heat, continue to be standard. The size of economizers, and the extent to which it pays to reduce the temperature of the escaping gases, are problems impossible of exact solution, depending, as they do, on the load curve and the price of fuel. Good authorities advise an amount of economizer surface varying from 10 to 40 per cent. of that in the boilers themselves.

In selecting and installing economizers care should be given to provisions for both internal and external cleaning, draining, by-passing, dampers, net gas area, supports, etc. Their use is accompanied by a material loss of draft, which must be made up by a chimney of greater height, or by mechanical apparatus.

Devices for pre-heating the air for the furnaces, either by the heat of the waste gases, or that of exhaust steam, have often been suggested, but on account of structural difficulties they have been used but rarely. Their cost, lack of durability, space required, and air friction, are serious obstacles to their general adoption. This feature would seem, however, to be worthy of further study.

Boiler feed pumps to economize steam, should preferably be of the crank and fly-wheel, motor or engine-driven type, with vertical outside packed plungers. They should have variable speed control, with quite low minimum speeds. There should be at least three units, any two of which to be capable of doing the maximum work. They should be conveniently located, in good light, and with ample room around them.

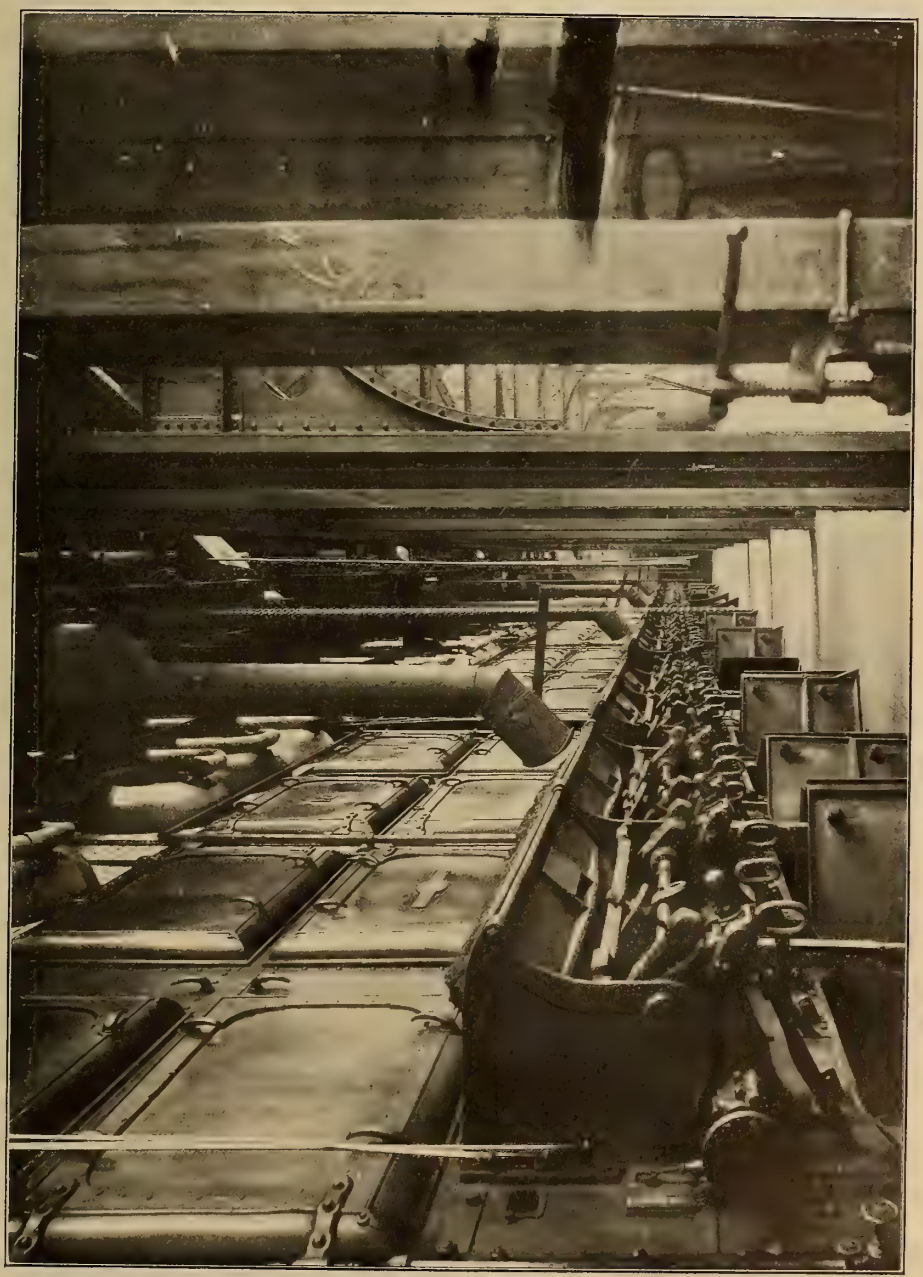
At best the auxiliaries are of much lower steam efficiency than the main generators, and much can be done to make them less wasteful. Just how far it pays to carry this idea is, however, a problem which must be solved independently for each particular case. Feed water from condensing engines is necessarily of low temperature, and the exhaust from low efficiency auxiliaries is often of great value in raising this temperature. When their exhaust can be thus profitably employed, their additional advantages of simplicity, reliability and low first cost are strong arguments in their favour.

A minor but still important detail is that of automatic stop valves on the main steam outlets from the boilers. Several designs of these are now to be had—which close in case of abnormal discharge of steam, and also when the current is reversed, as in the case of a ruptured tube or plate in the boiler itself.

ARRANGEMENT.

This depends, of course, upon the size of the plant, the value of ground space, the character of the load, size of units, their type, etc. Not many years ago it was good practice for a line of boilers to parallel a line of engines, back to back, each requiring about the same width of space in the station. With the development, however, of larger engines, their space requirements have grown relatively smaller, so that two boiler units—set opposite a central gangway—often serve a single engine. With steam turbines the disproportion is even greater—four or more boiler units of the largest size often being necessary. These may be set in rows leading off from the turbines, or they may be in double-deck boiler houses —where two stories of boilers fed from common coal storage bins overhead, are sometimes found.

Here, indeed, will the ability of the designer show to best advantage. Avoiding reckless extravagance in the use of space, and bearing in mind the advantages of compactness, he should nevertheless insist on ample room for access to all parts of every boiler unit, not only for the regular duties of operation, but for inspection, cleaning, repairs, etc. Easy access, by permanent and frequent stairways, should be provided to the tops of the boilers, with runways to all the valves. There should be good



BABCOCK & WILCOX BOILERS, EQUIPPED WITH ROney MECHANICAL STOKERS AND HUNT TRAVELLING WEIGHING COAL-HOPPER AND CHUTES

EDGEMOOR BOILERS, WITH HUNT FLOOR AND INDUSTRIAL RAILWAY, AT RIDGEWOOD PUMPING STATION

light, positive ventilation, ample toilet facilities, baths, lockers, etc. The entire plant should, if possible, be located above ground level. Provide the attendant with an ample supply of good tools, and a suitable place to keep them. Give him reserve parts in plenty.

Finally, give to the boiler room a modicum of finish—just a trace of the artistic, if you can, in finished walls of white, good floors, neat stairways, nickel-plated fittings and polished brass. Make it a place you are proud of—where you are willing to take your friends—one that can and will be kept clean and neat. You may be sure the attendant will take a pride in it as well, and you will help to set a standard of efficiency which will be reflected when your balance sheet comes around.

And when you have done all this, remember the man himself—the attendant—for on him depend the results which will actually be attained in every day working. See that the chief—the high-priced man, of white shirt and elegant demeanor—gives something of his time to the boiler room. Pick the best men for assistants—down to even the humblest coal passer. Acknowledge and encourage efficiency.. Employ brainier men and pay them well—for it is not desirable work at best—and they have their hands in your pocketbook every hour of the day.

Surely there is nothing impossible—or even difficult—about all this. One might even deny that the saying of this word meets any present need. But the doer of these things shall not fail of his reward.

Current Topics

IN one of our leading articles in this issue Mr. Lart calls attention to the extent to which improvements may be made in the design and construction of locomotives by using the special modern steels and by applying each variety to the use to which it is best adapted. This discussion calls attention to a matter which is continually appearing in engineering matters and which cannot be too strongly emphasized.

Different departments of engineering work become standardized, which is all right, and then they get into deep grooves, which is all wrong. Things are done in certain ways because they have always been done so, and any innovation is dismissed with the final opinion that "we do not do it that way," and in too many instances important improvements are long delayed because some earlier standardization has become crystallized into a hardened opposition to anything which is new.

When a new industry arises it is not yet hampered by any ancient traditions, and is free to avail itself of the best which presents itself. Thus the automobile industry, realizing the importance of the union of strength with lightness, is altogether alive to the advantages which the modern alloy steels offer in construction, and the combination of toughness, strength, and stiffness, which the chemist and physicist have to offer, is promptly accepted and effectively used. The locomotive builder, being much older in the game, is not to be deceived by any such innovations, not he! He believes in the old materials, tempered by a factor of safety which is so far on the right side that it leans over the other way, and he is handicapped by weights and masses which give him much trouble, but to which he clings with the fondness of age and conservatism. Mr. Lart is altogether right. The locomotive designer needs to be stirred up, and if he does not respond to the prodding he may awake to find it too late, when the electric motor and the automobile have left him in the rear, and he is hopelessly relegated to the museum of ancient mechanical curiosities.

THERE are some features about technical and other educational institutions which would be amusing if they were not so discouraging. Somewhere about three hundred years ago, after the revival of ancient learning in Europe, the development of classical training reached a point at which it was

rightly recognized as being the highest form of mental training then available. Mathematics was limited to the repetition of the propositions of Euclid; the sinister symbols of the algebra of the Arabian had not yet proved their real value, and the mediæval university represented the highest ideal in the scheme of education. The law of inertia, that property by reason of which a body tends to remain in the condition of rest or of motion in which it already is, continued to be most powerful, and it is even yet apparent that, in spite of the development of applied science, the mediæval type of educational institution holds its self-assumed position as the leader.

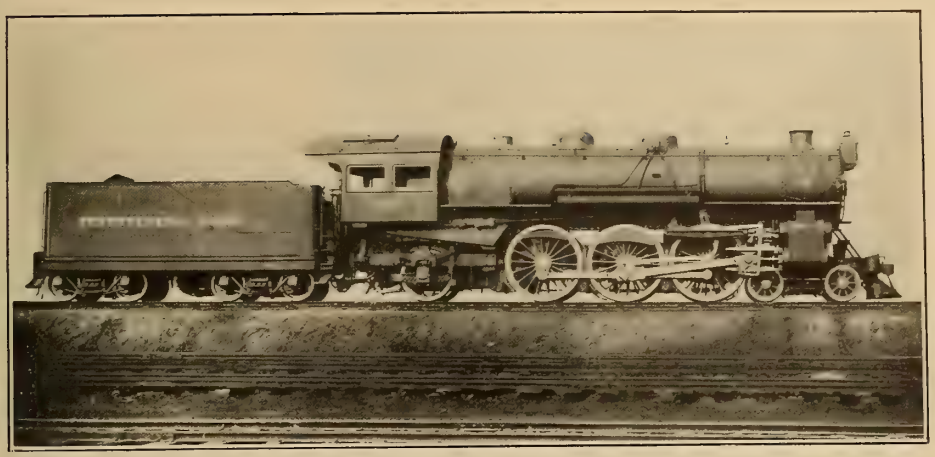
Meanwhile the world itself, ignoring the movements of the beings which temporarily occupy certain portions of its surface, continues to move; even as one Galileo bravely said it would, regardless of certain ecclesiastics who desired him to think otherwise, and colleges, universities, and even technical schools are found appealing to the men who have compelled the forces of nature to yield up some portion of their value, graciously to endow them with some of the leavings from their tables.

In such matters the older institutions have a greater share of worldly wisdom than their newer rivals. They understand that men may be reached through their play more easily than through their work. Ingeniously they have developed certain forms of amusement which they exploit as attractions, and appeal to the deeply interested world through such profound performances as the ability to kick a ball or to propel a boat through the water by muscular effort as examples of their worth and merit as institutions for mental culture. The technical school has a far greater basis for appeal for support and endowment; it is the place where the men who do things, who add to the real wealth of the world, have learned how to compel the forces of nature to deliver themselves to the use and service of man, and to it should rightly come some portion of the returns which it has enabled its pupils to acquire. Surely, the man who builds a railroad, who bores a tunnel, who develops a mine, in short, who "directs the great sources of power in nature to the use and convenience of man," is more worthy of note than the man who only knows "what has been done and who did it." Surely, the institution which has taught him how to subdue the forces of nature and to compel them to yield up the only real value which exists in the world to-day, is entitled to its tithe of his work.

It is a matter for interested curiosity to note that the men from whom the largest gifts and endowments to technical education come are those who have not had the advantages of that education themselves, and who, in spite of this lack of technical training, have succeeded in extracting from the hard-bound bonds of nature some portion of the wealth which she holds in her bosom.

Endowments of this sort cannot be looked upon altogether as gifts, as formerly was the case. To-day the manufacturing industries are largely dependent upon the product of the technical schools, upon the trained engineers and technologists for their commercial success, and the scientific school may properly be regarded as a preparatory department for the men who are essential for the continued prosperity of the industries from which the endowments must come.

The arts and the humanities are all right; they represent the sweets of life, the intellectual joys which remain for those who are privileged to enjoy them. To them, and possibly before them, however, come the realities of life, the command of the forces of nature, the control of the powers of the earth, the sea, and the air, and it is to this control that the activities of mankind to-day must be directed first; after that battle is won there comes the rest that remaineth.



PACIFIC TYPE (4-6-2) PASSENGER LOCOMOTIVE FOR THE PENNSYLVANIA RAILROAD

THE increased length and weight of passenger trains in the United States is demanding heavier and more powerful passenger locomotives, and on the Pennsylvania Railroad there has been installed for trial service a locomotive of the so-called Pacific type, or 4-6-2 arrangement. The general appearance of this powerful passenger engine is well shown from the photograph, and some of the data concerning it will be of interest.

By using six driving wheels, instead of the four drivers of the Atlantic type now employed for this traffic, the weight on the drivers may be kept below 60,000 pounds, while the tractive power reaches 15½ tons, or 22 per cent. greater than with four driving wheels. The total weight of this engine, with water in the boiler, and in running condition, is 134.6 tons, or the engine and tender together weigh 204.6 tons. As shown in the photograph, the Walschaert valve motion is used, the cylinders being 24 inches in diameter by 26-inch stroke, the steam pressure being 205 pounds per square inch.

In considering the endurance of modern steel rails, some of these dimensions may well be borne in mind, and the frequent passage of trains of ten or twelve heavy passenger cars, drawn by such an engine, should be considered as a possible element in the failure of rails of material and section designed for less severe service.

WE have discussed elsewhere in this issue the relations which the development of steam navigation and submarine warfare bore to certain historical matters about one hundred years ago. Human nature has not materially changed since then, and we still find that organized officialdom has nearly the same power to retard human progress that it had at the beginning of the last century. To-day the petty officer of the line does not hesitate to assume his superiority to the engineer, the man upon whom the effectiveness of the navy really rests; to-day any man who wears a uniform considers the civilian his inferior, even though that citizen be a Fulton, an Ericsson, or a Parsons. The government of France rejected the demonstrated plans of Fulton, even though those plans would have given her an immeasurable advantage over her opponent, solely because a martinet of an admiral objected to giving the civilian and his brave comrades commissions in the

French navy. The plans of Ericsson were rejected by naval officers, and only given a chance to save the Government because the Secretary of the Navy yielded to the persuasive powers of the engineer. To-day the turbine of Parsons is just beginning to be appreciated in naval service, after official indifference has tardily been overcome.

It is the old story of the assumed superiority of the man in office to the unofficial individual who comes before him, the assumption that capacity and ability are governed by official position rather than by fact. The time will come when the administration of national defense, as well as other national matters, will be conducted according to principles which already obtain in commercial affairs, and when results will count regardless of their origin. Sometimes, unhappily, commercial interests fall foul of each other, and a conflict of wits, of resources, and of abilities follows, and the methods which are then adopted might well give lessons to the men who hold the control of the fighting machinery of governments, while at the same time ignoring the engineers by whom alone that machinery can be successfully operated.

THE term labour-saving, as applied to tools, is generally assumed to mean the saving of the cost of labour, and in many cases this is undoubtedly the correct meaning. There are numerous instances, however, in which the tool enables work to be done which would be impracticable in any other manner, or for which ordinary hand methods would be prohibitive in cost. An excellent example of such a case is seen in the manner in which the oxy-acetylene blowpipe is applied to produce welded seams and joints, as illustrated in the paper of Mr. Cutler, elsewhere in this issue. It is not sufficient to produce a high temperature, but it must also be produced in such a controllable form that it practically becomes a tool in the hand of the skilled workman, enabling him to fuse almost any metal along any chosen line, either for purposes of welding or of cutting. The blowpipe thus becomes a new tool, in the same sense as the term is applied to a chisel, a file, or a drill.

Another instance of the production of an instrument which renders possible operations formerly impracticable, is seen in the modern pneumatic tool in its numerous modifications. The pneumatic hammer, whether used for chipping, riveting, or cutting, enables access to be had to difficult locations and permits work to be done with speed where otherwise it could scarcely be done at all. Thus, the pneumatic hammer has been used to reface a mudhole flange on the inside of a marine boiler, detaining the vessel only a few hours, while the leaky joint could otherwise not have been repaired without expensive delay. Another instance is that of the boring off of wooden piles by a diver in deep water, the pneumatic drill increasing the rate of this difficult work ten times over hand boring.

It is becoming realized more and more that the real value of machinery is not merely to reduce labour costs, but, so far as possible, to do away with severe manual labour altogether. The press supersedes the hammer, the grinding machine takes the place of the file, while the turret lathe, especially in its automatic and semi-automatic forms, reduces manual labour to a minimum, making the man work with his head instead of his hands.

INDEXED

HARRIS & EWING, WASHINGTON, D. C.

HON. JOHN BARRETT

DIRECTOR BUREAU AMERICAN REPUBLICS, WASHINGTON, D C.

(See Page 559)

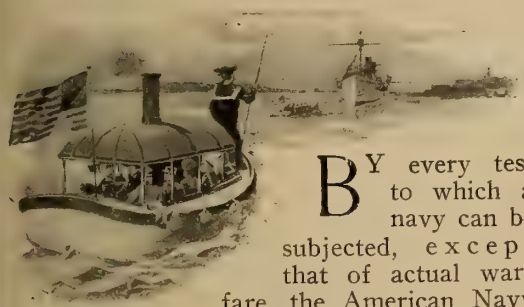
CASSIER'S MAGAZINE

VOL. XXXII OCTOBER, 1907 No. 6

THE AMERICAN FLEET FROM AN ENGLISH POINT OF VIEW

By Archibald S. Hurd

It is well known that distance is necessary in order that a proper perspective may be obtained, and it has been fully recognized that for a proper critical view of such a subject as that treated by Mr. Hurd, a judicial opinion can best be formed by an expert who is free from local prejudices and impressions. Mr. Hurd's familiarity with naval conditions in Europe and America renders him especially well qualified to discuss the strength and weakness of the American navy, and his views will be read with much interest. The present paper forms the first portion of his discussion, and the second and concluding part will appear in a subsequent issue.—THE EDITOR.



BY every test to which a navy can be subjected, except that of actual warfare, the American Navy to-day ranks unquestionably as the second greatest naval force in the world. In the development of sea power there is no parallel to the expansion of the American Navy which has taken place during the past twenty-five years, and more particularly in the last decade. A quarter of a century ago this fleet, in contrast with the naval forces of other great Powers, was of the slightest importance. It had been rigorously starved. Congress had for years failed to make provision for new men-of-war and severe limitations had been imposed upon the Navy Department to prevent any considerable additions being made to the number of officers and men. In 1883 the entire expenditure upon the navy, including the cost of new construction, the maintenance of the naval establishments ashore, the pay of officers and men, and all the expenditure associated with sea training, amounted to two and a half million sterling only.

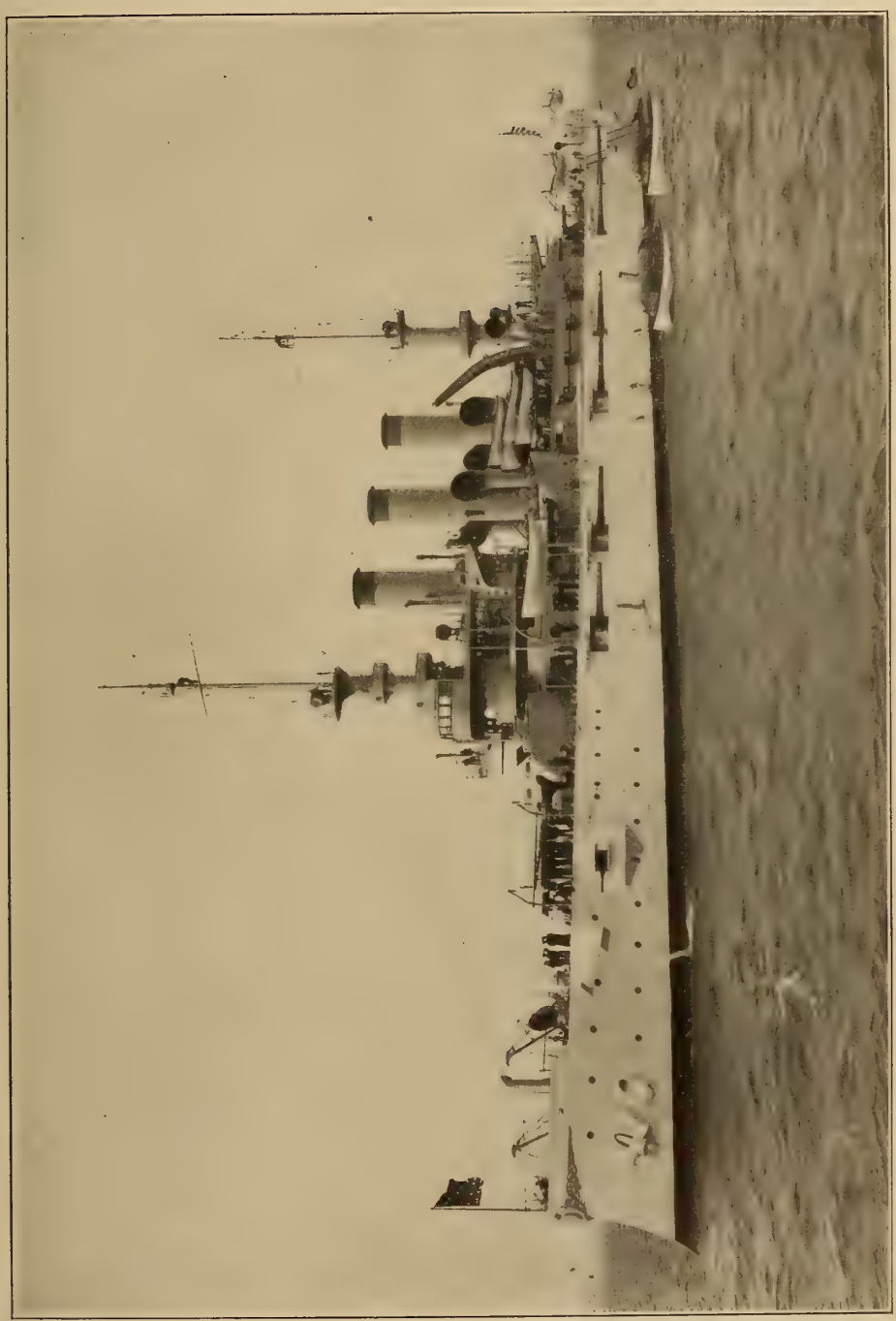
In succeeding years the growth of the fleet was kept under severe restraint, and practically down to the time of the war with Spain the navy of the United States ranked as one of the smallest in the world. In fact on the outbreak of hostilities many European officers formed the opinion that the American fleet was not equal to the task which it had undertaken. It was the fashion at that time to measure sea power almost exclusively by the number of ships built or building, and to attach little importance to the personal equation, the relative efficiency of the crews in gunnery and other drills, and the aggregate numbers of officers and men. As the campaign developed, American officers and men revealed to the world a

Copyright, 1907, by the Cassier Magazine Co.

capacity for war afloat which quickly convinced all observers that the American fleet was certain of victory. Whatever other results may be attributed to the conflict, it had two conspicuous and important developments; it showed Europeans that, in spite of the marvellous commercial and industrial development of the republic, the personnel of the American fleet, small as it was, was eminently well-fitted for naval operations. Officers and men brought to their task afloat the same resourcefulness, high intelligence, and enterprise as the American people had given to the building up of the supremacy of the United States on the American continent. The war laid one of the lingering traditions by which in the past the relative capacity of the respective fleets had been measured. It was proved that technical skill in naval warfare, combined with iron nerve, was of more importance than the ancient lore of seamanship which had been handed down from the sail era. Naval power was seen to depend largely upon technique—skill in the design and construction of ships of war which is to be found only in a country with a large steel and iron industry—and mechanical ability essential to the proper control of the complicated boxes of machinery which have superseded the old picturesque sailing ships of the past.

These were the general lessons which the war taught to the naval powers of the world, but the contest also raised the pride of the American people in their fleet. In the intervening years the expenditure upon the navy has increased from just over six millions to, roughly, twenty millions sterling, and the current year's expenditure marks an increase even upon the figures of the year which has just closed. The American people are now devoting to their fleet nearly twice as much money as is being spent by either of the great continental Powers of Europe, in fact almost as much as France and Germany combined, though still about thirteen millions sterling less than Great Britain. Relative naval expenditure is, however, not an accurate and reasonable guide to the standings of the respective fleets. European navies of the continental Powers are manned under a conscriptive system, and consequently the rate of pay for officers and men is low. On the other hand, in the United States the naval authorities are handicapped by the great demand for labour ashore and the high rate of wages and exceptional standard of comfort which rule throughout the American States. Consequently, officers and men are paid at much higher rates than in the British fleet, and even more disproportionately in contrast with conscriptive navies, and they expect a higher level in the amenities of life on board ship and in naval establishments ashore. The American people are compelled by the economic conditions which prevail in the United States to buy their sea power in the most expensive market. The expenditure, on the other hand, has been on such a lavish scale in contrast to the appropriations, even as lately as ten years ago, as to place the American fleet next to that of Great Britain.

Last year the naval authorities were able to complete for sea a larger number of battleships than were added to any other navy—not including Great Britain. No fewer than seven battleships were completed for sea in this period, an accession to naval power without parallel in the development of naval power in modern times. Indeed, the progress which is being made in adding to the material of the American fleet is ample assurance that this national naval force will not merely maintain its present position, but will continue in the next few years to still further outdistance the navies of France and Germany. The standing of the fleet of the United States in first-class battleships in contrast with the other great navies of the world three years hence, when the vessels now under



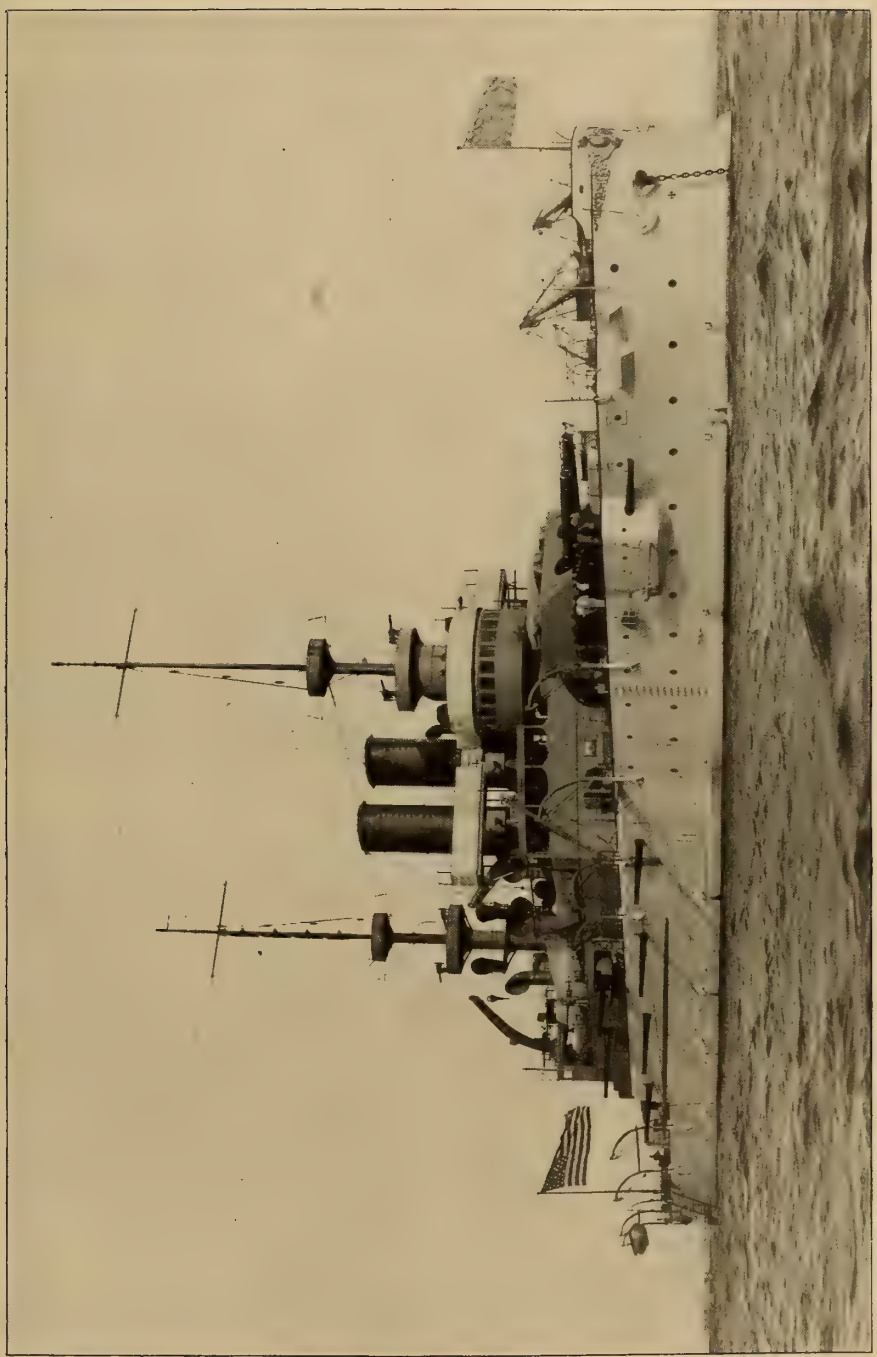
PHOTOGRAPH COPYRIGHT BY WILLIAM H. RAU, PHILADELPHIA

UNITED STATES BATTLESHIP "LOUISIANA"

construction are complete, will still be far below that of Great Britain but will be considerably in advance of that of any other Power. At that date—that is, in 1910—the number and tonnage of the first-class battleships will be as follows:—

	Number.	Tonnage.
United States	29	405,847
Germany	28	355,566
France	23	321,977
Japan	13	190,844
Russia	8	110,952
Italy	8	95,418

The American fleet has the ships, but the grave defect in the organization is the lack of sufficient officers and men. Calculated on the basis of personnel, the American fleet ranks below that of Germany, France, and Japan, not only in number of officers and men on the active list, but in the size of the reserves available. In all European navies the regular personnel is supported by a large and more or less well-trained reserve which includes officers and men. Too much importance may be attached to this feature of the naval organization in Europe, because war experience has shown that the wastage of men will be far less serious than the wastage of material. In other words, the casualties of naval war are not so devastating as is often imagined, and the same officers and men, with no very large deductions for casualties, will be available throughout the whole course of a campaign, their value as a national asset increasing as they gain in nerve and experience. The same officers and men who man the fleet when it is first mobilized will be returning again and again in transports or otherwise, or with the vessels which have suffered serious injury and will be available to commission ships hitherto in reserve. Nevertheless, some margin in personnel is essential in order to make good the possible losses of war. In the American fleet the personnel is very small in comparison with the size of the navy. The American people can obtain as many ships as they care to pay for, but at present the rates of pay, high as they are, do not attract sufficient numbers in spite of the wide net which is spread by the recruiting officers. This is one of the disadvantages, and they are not many, of the abundant prosperity which has been experienced throughout the republic of late years, and will prove probably the main obstacle to the growth of the naval power of the United States. The difficulty will continue to increase the more energetic the policy of shipbuilding. The fleet is expanding rapidly as battleships, cruisers, and torpedo craft are completed and sent to sea, and unless some solution of the manning problem is reached at an early date, the personnel resources of the United States will be so restricted as to force the naval authorities to place in reserve with no crews ships of considerable fighting value which under more fortunate circumstances would be kept, if not in full commission, at any rate with nucleus crews on board. No doubt something could be done to alleviate this source of trouble if the population ashore realized the dignity which attaches to voluntary service in a fighting force, and treated men of the lower deck when ashore with more consistent kindliness and consideration instead of, as has not infrequently happened, regarding them in the light of social lepers. This change of public feeling will become all the more necessary the more widely the fleets and squadrons are distributed. The war with Spain, which left the United States burdened with the responsibility of defending the Philippine Islands against all comers, has cast upon the navy the responsibility of defending these distant possessions. In the future it will be essential for the Navy Department at Washington to detail a large fleet for service in Far Eastern waters, and the period of service will be necessarily of considerable duration, because owing to the long voyage between American ports and the Philippines it will be impossible



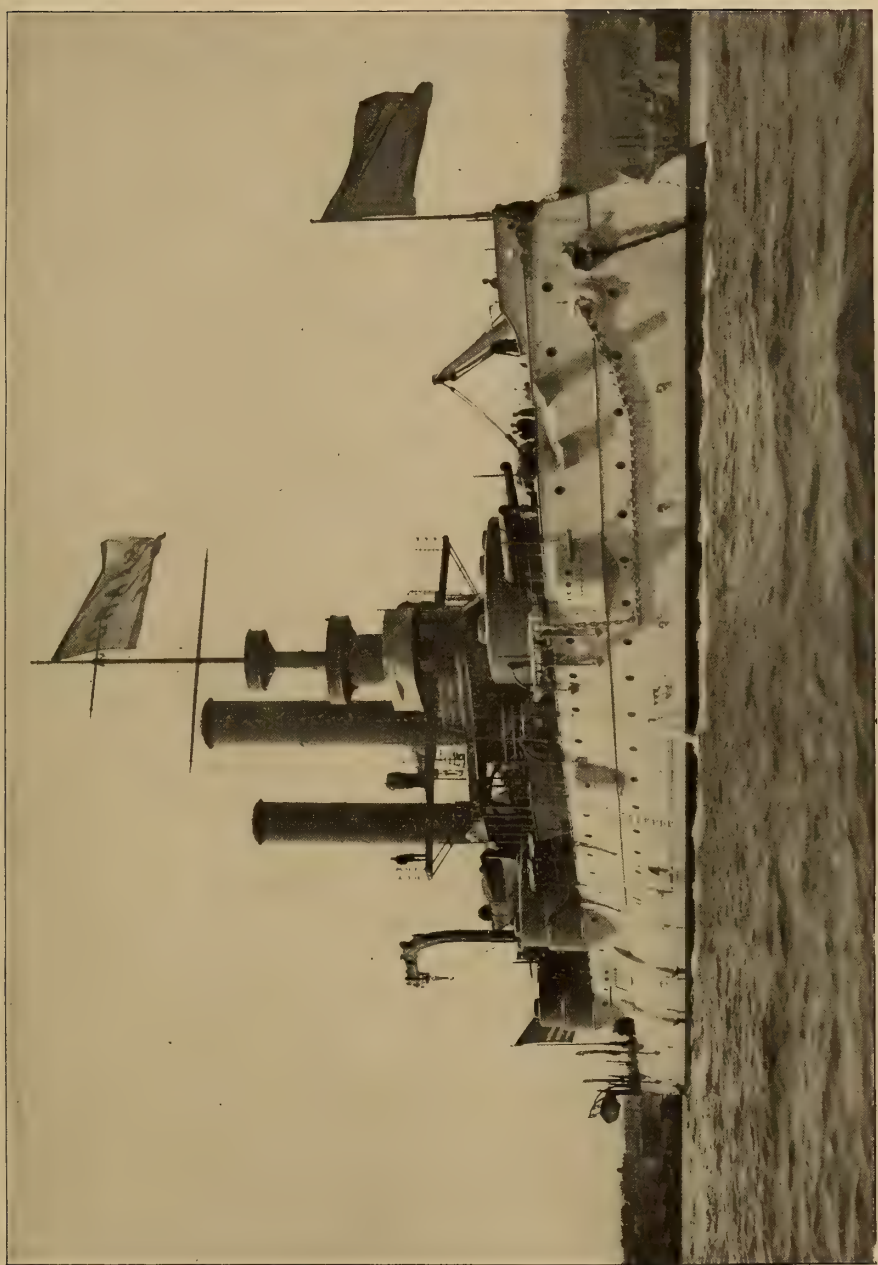
THE UNITED STATES BATTLESHIP "ALABAMA"

COPYRIGHTED BY A. LOEFFLER, NEW YORK

to effect the relief of crews at frequent intervals. Though service in distant seas may be attractive to a large number of the young officers and men of the fleet who are keen on change of scene and adventure, service in the Philippines, in an enervating climate, will probably become increasingly unpopular and will thus tend still further to embarrass the Navy Department.

At the present moment the United States possesses a fleet in which a natural pride may legitimately be taken. The navy has already benefited by the energetic naval policy which has been pursued of late years. Never has the construction of ships for warlike purposes been so active on the American continent. Construction, it is true, proceeds far more slowly than in Great Britain or Germany, but this is not entirely due to the industrial conditions. Congress still continues to keep a firm hand upon the expansion of the navy, whereas the great fleets of Europe are developed almost entirely on the sole responsibility of the experts at the several admiralties within the financial limits laid down by the respective governments. In the British fleet, the shipbuilding programme from year to year is developed by the Admiralty without consultation with the House of Commons; and legislators, recognizing that naval defense is a technical subject, never press criticism to the point of forcing upon the naval authorities any variation of the programme submitted, or any changes in the types of ships to be laid down. In recent years the House of Commons has sanctioned shipbuilding without obtaining any details of the character of the vessels to be laid down. Year by year the Admiralty applies for authorization of a programme which is submitted in the barest skeleton; the numbers of battleships, cruisers, and torpedo craft are stated numerically and the designs are developed by the Board of Admiralty in complete independence of legislative interference. The programme is always known to the Cabinet in greater detail, but the House of Commons is usually in ignorance of the exact manner in which the sum appropriated to new ships is being spent until the vessels are far advanced, and then not infrequently the information leaks out through the press unofficially and is not formally communicated to Parliament. Since success in war depends largely upon the secrecy observed in preparation for it, it will be generally admitted by naval officers that the British system is one which confers upon the Admiralty no slight advantage. This principle of the independence of the experts applies also to almost every detail of administration. Officers are promoted and receive appointments, changes are made in the terms of service, naval establishments are abandoned or expanded, and the whole machinery for the preparation of war is carried on by the board, the only check being the power retained by the Cabinet to intervene. Seldom do the ministers of the Crown as a body interfere with the administrative freedom of the Cabinet minister at the head of either of the fighting services.

In the United States the naval authorities do not enjoy the same freedom. Congress exercises its right to supervise the exact types of ships which are to be built, and general particulars are embodied in an act thus formulated, tying down the naval administration. This system leads to many delays, which may be illustrated by quoting the case of the battleships for which tenders have lately been accepted. Early in 1906 Congress called upon the Navy Department to prepare a general scheme of design for a battleship which it was insisted should be superior to anything which was being built abroad. Not until twelve months later did the Navy Department have an opportunity of submitting its suggestions, and in the meantime the British battleship *Dreadnought* had been built and completed for sea, and the three



COPYRIGHTED BY A. LOEFFLER, NEW YORK

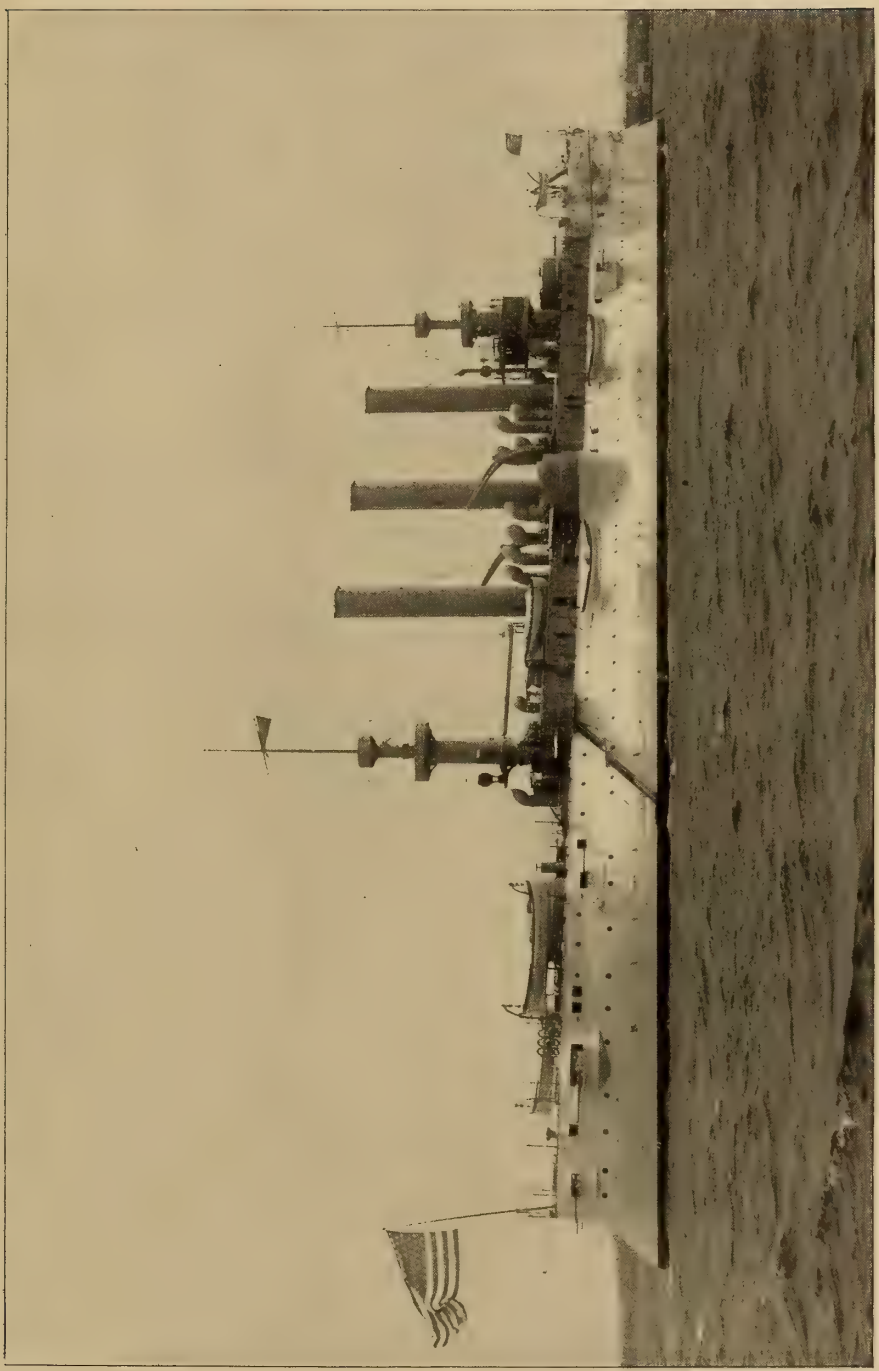
THE UNITED STATES BATTLESHIP "IOWA"

Indomitable cruiser-battleships far advanced. The British authorities, in virtue of the confidence reposed in them, were able to gain an advantage of twelve months in the construction of ships of the new design without revealing even the general details of the ships building.

The delays in naval construction are not, however, confined to the interference of Congress. The American Navy Department is divided up into a number of subdepartments, as in the British service, but the American subdivision is much more complete and the references from one department to another are far more formal, with the result that the work of ship design and construction is not pursued with concentrated effort, which leads in the case of British men-of-war to very rapid construction. In Great Britain the Board of Admiralty is supreme, and day by day not only exercises its authority, but is in complete touch with all the developments which are under consideration in all the different sections of the administration, with the result that as the work of design and construction proceeds all the details are made almost imperceptibly to dovetail into one another without loss of time or waste of effort.

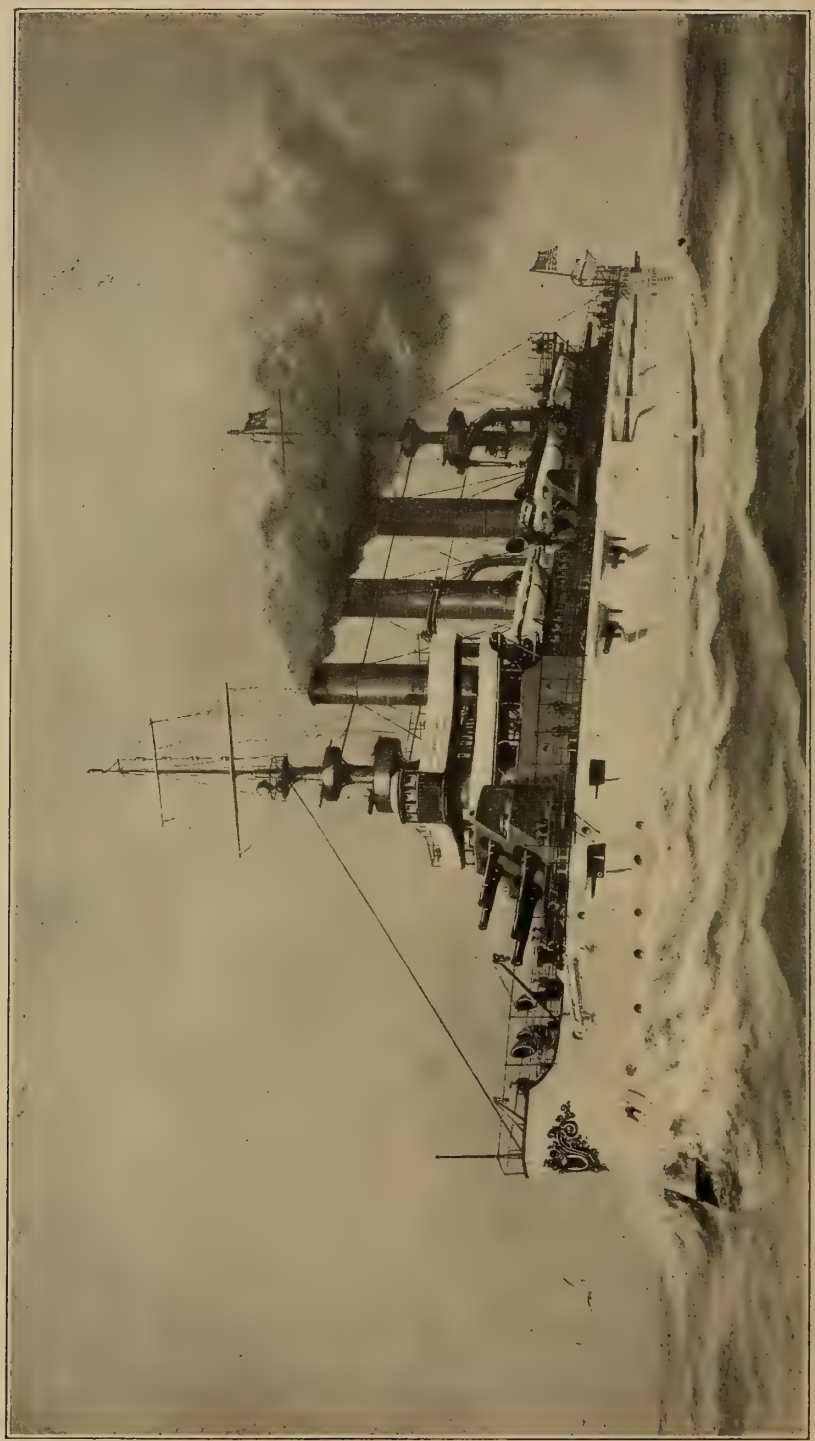
It may be also that the American navy suffers somewhat from its virtues. The technical officers of the American navy are above all things enterprising and are continually reaching out for the latest developments in mechanical equipment for war; they are ambitious to make progress, and this very spirit has in the past frequently led to vital changes in design after ships have been laid down, and thus contributed to slowness of construction, besides embarrassing shipbuilders and adding to the cost. As a general principle in the British service vital alterations, once the type or the class has been designed, are seldom permitted. The name ship is not laid down until all the expert advisers of the Admiralty have expressed their concurrence in the compromise which has been evolved from all the divergent views and after the tank and other experiments have been completed, the parent ship of a class is laid down and that class is completed with little or no variation between the various units. This rigidity of construction has led to a standardization which exists in full measure only in the British and German navies and results in seagoing squadrons having the immense tactical advantage of homogeneity. In the American service the advantage of this system has been increasingly recognized in recent years, and the fleet has now secured a large measure of homogeneity in modern battleships and the larger type of cruisers.

This year the United States has in commission and under continuous training the finest battle squadron to be found in any of the world's navies. It has only this one strategical unit of battleships, it is true, in contrast with four under the British flag, but the point is that it is Rear Admiral Robley Evans's proud distinction to command a war force which is more powerful in battleships than the German High-Sea Fleet, and compares not unfavourably with the British Channel Fleet of fourteen battleships which Admiral Lord Charles Beresford has under his orders. The German High-Sea Fleet includes the same number of battleships as are under Admiral Evans, but they are not of equivalent fighting power, as eight of them carry nothing more formidable than the 9.4 inch guns of 40 calibres. On the other hand, the sixteen American ships mount heavier primary weapons and are superior ships in most respects, particularly now that the *Vermont* and *Kansas* have replaced the older and smaller ships *Iowa* and *Indiana*. The Atlantic Fleet as it is now constituted—and it will be more powerful next year—is one to fill the American people with pride. It includes the following battleships, cruisers and torpedo craft, with a number of fleet auxiliaries, the



COPYRIGHTED BY A. LOEFFLER, NEW YORK

THE UNITED STATES ARMOURED CRUISER "BROOKLYN"



UNITED STATES BATTLESHIP "NEW JERSEY"

COPYRIGHTED BY C. McKNIGHT SMITH

importance of which the American authorities were among the first to recognize.

There is no more powerful command in any fleet in the world than this of Admiral Evans. It is complete in all the several arms, though, according to European standards of strength, it is unduly weak in modern torpedo craft. On the other hand, it is well provided with auxiliaries, including a water-ship and a refrigerating vessel. The war with Spain showed the American Navy Department the immense importance of having auxiliaries ready and accustomed to act with the war fleet. Such ships are all important, and of late years great attention has been directed by the British Admiralty to this form of equipment, although for war it is intended to rely largely for collier and certain other ships upon private owners.

Atlantic Fleet.	Launched.	Displacement. (Tons).	Main Guns. (Inches).	Speed. (Knots).
Rear Admiral Robley D. Evans, Commander-in-Chief.				
First Squadron—First Division.				
Connecticut (Flagship of Rear Admiral Evans)	1904–1905	16,000	4—12-in. 8— 8-in. 12— 7-in.	16
Louisiana				
Kansas				
Vermont				
Second Division.				
Rear Admiral Charles M. Thomas, Commander.				
Virginia (Flagship of Rear Admiral Thomas)	1904	14,948	4—12-in. 8— 8-in. 12— 6-in.	19
Georgia				
New Jersey				
Rhode Island				
Second Squadron—Third Division.				
Rear Admiral Charles H. Davis, Commander.				
Alabama (Flagship of Rear Admiral Davis)	1898	11,552	4—13-in. 14— 6-in.	17
Illinois	1898	11,520	4—13-in. 8— 8-in. 14— 5-in.	16
Kearsarge				
Kentucky				
Fourth Division.				
Rear Admiral William H. Emory, Commander.				
Ohio (Flagship of Rear Admiral Emory)	1901	12,500	4—12-in. 16— 6-in.	18
Maine				
Missouri				
Minnesota	1905	16,000	4—12-in. 8— 8-in. 12— 7-in.	18
Third Squadron—Sixth Division.				
Des Moines	1902	3,200	10— 5-in.	16½
Prairie (auxiliary)	1890	6,872	8— 6-in.	14½
Scorpion (schooner)	1896	850	.....	..
Tacoma	1903	3,200	10— 5-in.	16½
Fourth Squadron—Seventh Division.				
Dixie (auxiliary)	1893	6,150	8— 5-in.	16
Dubuque (gunboat)	1904	1,085	6— 4-in.	12½
Marietta (gunboat)	1897	1,000	6— 4-in.	12
Paducah (gunboat)	1904	1,085	6— 4-in.	12½
Second Torpedo Flotilla.				
Lieut. Com. Edwin A. Anderson (Flotilla Commander).				
Hopkins	1901–1902	408	2—14-pdrs.	29
Hull				
Stewart	1902	420	2—14-pdrs.	29
Whipple	1902	433	2—14-pdrs.	30
Lawrence	1900	400	2—14-pdrs.	30
Worden	1902	433	2—14-pdrs.	29
Third Torpedo Flotilla.				
Lieutenant Willis McDowell, Flotilla Commander.				
Stringham	1899	340	7— 6-pdrs.	30
Shubrick (torpedo boat)	1899–1900	165	.....	26
Thornton (torpedo boat)				
De Long (torpedo boat)				
Stockton (torpedo boat)				

Fleet Auxiliaries.

Abarenda (collier).	Brutus (collier).	Hannibal (collier).	Nero (collier).
Ajax (collier).	Cæsar (collier).	Leonidas (collier).	Sterling (collier).
Arethusa (water-ship).	Glacier (refrigerator).	Marcellus (collier).	Yankton (tender).

(To be concluded in the December issue)

COAL-DUST EXPLOSIONS IN COLLIERIES

THE INFLUENCE OF WATER AND STEAM ON COAL DUST, AS ILLUSTRATED IN THE WINGATE GRANGE COLLIERY EXPLOSION

By James Ashworth, E. M.

In view of the fact that numerous fatal disasters have recently occurred from dust explosions in coal mines, it is most desirable that the best methods of prevention be carefully examined, and their value, or otherwise, established. It has generally been accepted, both in Great Britain and on the Continent, that danger from dust explosions could be wholly prevented by watering, and until recently this method has been relied on by managers and owners for protection. Mr. Ashworth shows that it is entirely possible for serious disasters to occur in thoroughly watered portions of a mine, and his detailed examination of the explosion which occurred about a year ago at Wingate Grange Colliery seems to bear out his contention. Under such circumstances, the whole question appears to be re-opened, and it remains for colliery engineers to endeavor to find some more effective solution for the problem upon which such serious consequences depend.—The Editor.

THE British Blue Book report on the Wingate Grange disaster is of particular interest at the present time, when, in spite of the utmost care exercised by the managers of collieries, explosions both great and small continue to occur in all parts of the world. So lately as March, another great disaster was reported to have occurred in Germany, where, in accordance with the Dortmund order, watering has until very recently (the Reden explosion) been accepted and adopted as a sure preventative. Not only was the watering of mines in accordance with the above order believed to be a complete safeguard in Germany, but a special commission, consisting of two chief inspectors of mines, Messrs. W. N. Atkinson and Henry Hall, was sent by the British Government to investigate the subject, and they testified that, in their opinion, the German method of watering gave *absolute* safety. Only a few days after this opinion was made public, the whole theory was rudely upset by the Reden (Jan. 28, 1904) and then by the Klein Rosseln (March 15, 1907) explosions, both of which caused great loss of life.

With regard to watering the Wingate Grange colliery, Mr. A. H. Ruegg, K. C., reported that no attempt was made to water the sides and roof of the roadways, and that the floor was watered by tanks of water with the plug pulled out, and sometimes a pail was used to distribute the water over a large area of roadway, and therefore he assumed that the dust on the roof and sides was dry. The expert witnesses agreed that the watering of the roof and sides of the main haulage ways might be advisable, but that in some cases it would be attended with danger, and Mr. Armstrong, the manager, said that the roof and sides of the Low Main seam could not be kept constantly damp without such risk being incurred. Mr. Ruegg does not make any personal suggestions as to the watering, though he says "it may be that an effective system of watering in zones, and the removal, as far as practicable of dry dust by means of periodical brushing, may in the end be found to be the best means of securing safety."

The inspectors of mines, in their part of the report, do not in all their

FIG. 1.—WINGATE GRANGE COLLIERY EXPLOSION, OCTOBER 14, 1906. PLAN OF WORKINGS IN THE LOW MAIN SEAM. SCALE ABOUT 22 CHAINS TO THE INCH

fourteen conclusions, specify any recommendation as to watering, and likewise the jury made no suggestions. This point is particularly noticeable at a time when the popular opinion is, or has been, that "watering" is the sole cure of the coal dust disease, but Messrs. Ruegg, Bain and Atkinson all give particular attention to the "best mode of rendering harmless the coal dust which will collect on main haulage roads." In a mine like the Wingate, though it is not a particularly dusty one, Mr. Ruegg's strongest recommendation is that "all main haulage roads should, as far as practicable, be kept clear of dry coal dust, and he thought that this should be made compulsory"; he concluded with the opinion that an explosion, wherever and by whatsoever cause originating, would spread more rapidly and be rendered more serious if the haulage ways were dry and dusty.

Among conclusions of the mine inspectors were the following: (4), the inflammable agent both at the origin and in the propagation of the explosion was coal dust and not firedamp; (7), the explosion died out in all directions with the cessation of the supply of coal dust; (11), it is to be feared that the act of the stoneman indicates that miners do not appreciate the danger of coal dust; (12), we think that coal mines cannot be said to be reasonably safe so long as their main avenues constantly contain materials capable of producing a violent explosion in the shape of coal dust and pure air; (14), we urge that immediate steps should be taken to make obligatory the removal, and to prevent the accumulation of coal dust on the intake air ways and mechanical haulage roads of collieries; and they regretted that the jury did not see their way to state what in their opinion was the agent first inflamed, and the agent that carried forward the explosion, and finally, that they made no specific recommendation as to precautions necessary in the future.

The explosion occurred about 11:40 P. M. on the 14th of October, 1906, in the Low Main seam (Fig. 1), and at the time there were 204 persons under ground, of whom 55 were in the Low Main; 36 were in the Stable way district, 2 of these being killed, 1 by violence and the other by afterdamp; of the 13 persons in the Second East way, 9 were killed by afterdamp; 3 out of the 4 men in the First East way were killed by afterdamp; a shifter was blown into the shaft and killed, and a stoneman named Maddison was killed by violence and burning in the main haulage road near the First East way (Fig. 1). In the Main coal 1 man was killed by violence and 2 by afterdamp; and out of 26 persons working in the Five Quarters seam 5 were killed by afterdamp; 58 horses and ponies were killed, and 6 out of 8 which were at work survived.

The downcast shaft, 14½ feet in diameter, was fitted with two pairs of cages and wooden guide rods, and had a range of steam pipes from the surface to the Hutton seam, and also a second range of steam pipes from the Main coal to the Harvey seam. This shaft was wrecked and the steam pipes broken for a distance of 40 yards above the plane of the explosion, and below for a distance of 86 yards, viz., to the Harvey seam. At the Low Main in the upcast shaft the casing was blown away, but the two ranges of steam pipes were not broken in the shaft. These two ranges of steam pipes only existed to the Main coal, one being continued down the downcast shaft to the Harvey seam, while the other was carried down the Harvey staple pit to the Low Main hauling engine. From the Main coal there was also a drop staple pit to the Low Main, and from the Low Main a dumb staple pit to the Harvey seam (see Fig. 2).

The ventilation was controlled by a Waddle fan delivering 193,478 cubic feet of air per minute with a water-gauge pressure of 3 inches, and of this volume 36,348, say one-fifth, entered the Low Main, 10,140 cubic feet

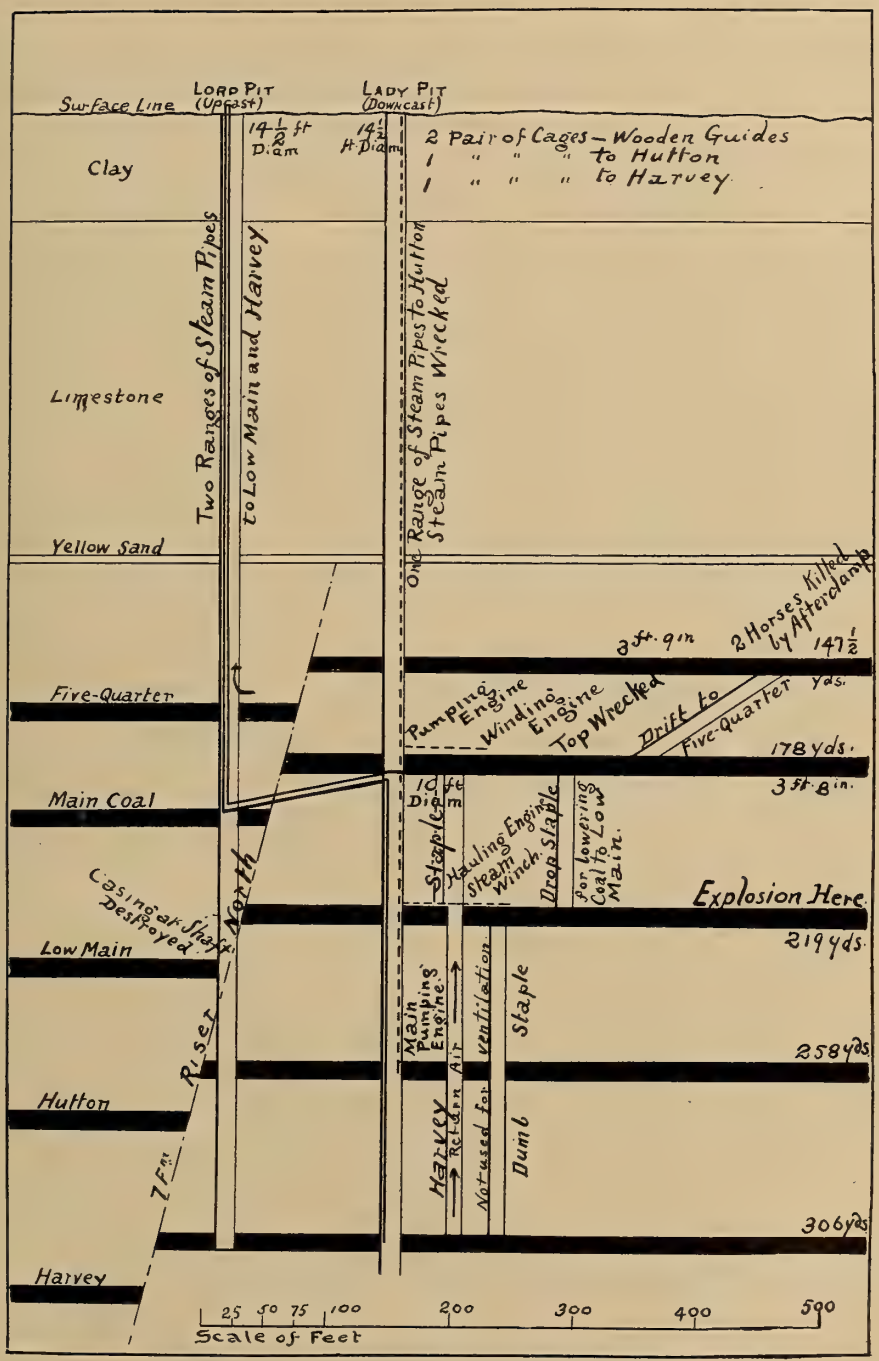


FIG. 2.—SHAFT SECTION AT THE WINGATE GRANGE COLLIERY

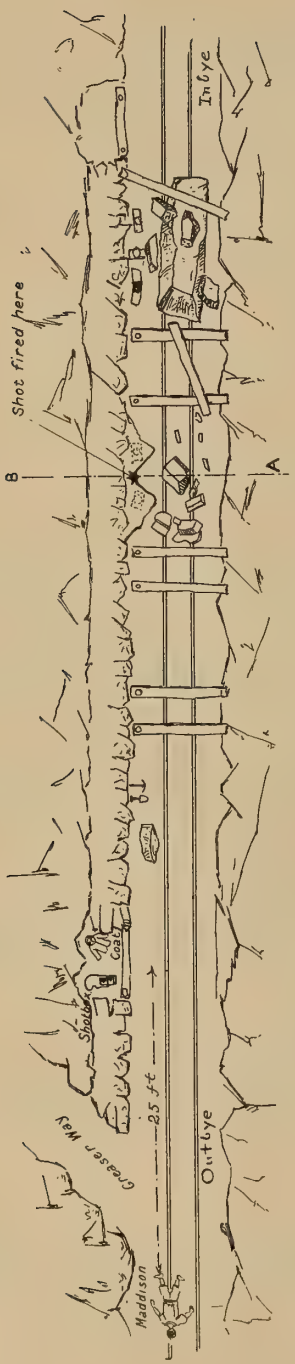


FIG 3.—WINGATE GRANGE EXPLOSION. PLAN OF PLACE WHERE THE SHOT WAS FIRED

going down the Stable way and 26,208 down the North East way, where the explosion originated.

Bonneted safety lamps of the Marsaut and Donald types were alone used, locked with lead plugs, and the officials had either similar lamps or Tin Can Davys, secured by screw locks. Some few naked lights were used on the roads as far as the caution boards.

Compressed gunpowder was used at the Low Main faces, and geloxite in the stonework, shots were fired by the deputies with heated wire and the geloxite by fuse and detonators. No person was permitted to fire shots without an authorization from the under manager.

Very little damage was done at the

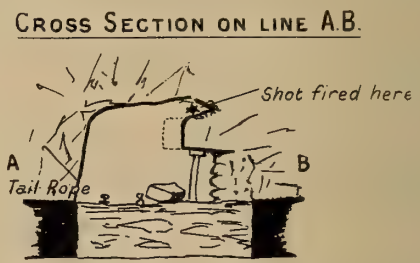


FIG. 4.—SECTION OF PLACE WHERE SHOT WAS FIRED

top of the pits, but in consequence of the damage in the downcast, the rescue parties had to enter by the upcast shaft at the Main coal landing, where they found the top of the Drop staple wrecked, and 22 men alive in the Five Quarter seam. The Low Main seam was reached by 1 A. M., or about 1⅓ hours after the explosion, and very little trouble was experienced from afterdamp.

The mine lies nearly flat, with a rise in a southwesterly direction, and produces bituminous household coal of good quality, and very little firedamp. The strata above the coal are not dry, and the roads affected by the explosion were stated by the inspectors of mines "not to be specially dusty." The flame of the explosion was found to have passed over two

portions where the bottom was wet, one of which, 40 yards long, had a sump on the side to collect water, but the roof and side were said to be dry.

It was admitted practically by everybody that the explosion had originated from the misuse of 6 ounces of geloxite, fired by a stoneman named Maddison, to blow down a piece of roof in the North East haulage road, and it was assumed that a mixture of grease and dust from the roadway had been used by him to cover the charge when laid on the stone. The road at this point was entirely in the roof stone above the coal, and the coal was not exposed. (Fig. 3).

The theory of the inspectors of mines, Messrs. R. D. Bain and J. B. Atkinson, was "that the explosion of the geloxite shook a cloud of dust into the air current and the flame ignited it; expansion due to heat then followed, and more dust was disturbed on each side, and the burning continued quietly over the length of undisturbed ground (90 yards), when the two diaphragms of flame, fully established, extended with violence in opposite directions as far as the supply of coal dust continued.

"That the coal dust on the roads was caused (1) by that blown off the trains of loaded tubs; (2) by that blown from the tub while being drawn up the downcast shaft; and (3) by that brought from the screens on the surface by the air current passing down the shafts.

"That the first condition necessary to the existence of coal dust on roads in a mine, is sufficient dryness." They remark, however, that the air of the Low Main seam was not particularly dry, yet that the hygrometrical observations they made, indicated a sufficient degree of dryness to allow of the accumulation of dry coal dust.

These observations in themselves form a very interesting study, when it is added that the shafts were naturally wet, and also heated to some extent by the steam pipes and escapages of steam, and it may be queried what real indication there was of dry coal dust.

At the time the observations were made the damage in the downcast shaft had not been repaired, and therefore the dampness naturally caused by the steam pipes was absent, but the inferences drawn by the reporters from their observations was that the roads showed "a sufficient degree of dryness to allow of the existence of dry coal dust at the point where the shot was fired."

This opinion is very important at a time when watering, spraying and other means of applying water are being urged as the cures and preventatives of, and the extension of explosions, as well as of their initiation, and as we have no better scientific instrument than the arrangement of wet and dry thermometers known as the hygrometer, to show us whether the mine air is dry or damp, we must look to the reported observations to prove the inspectors' assumptions. On the 22d of October the surface air contained 4.8 grains of water vapour, which was only 0.4 grains less than complete saturation; at the Low Main seam, in the intake at the shaft the air was absolutely saturated, and having taken up nearly 1 grain of moisture in the shaft, carried 5.7 grains; at the place where the shot was fired the heat had increased 3 degrees, and the water vapour had decreased 0.3 grains, but at the curve of the Second East way the heat had gone up to 64 degrees, and the water content to 6.2, or within 0.2 grains of complete saturation, and it is therefore clearly shown that the road was sufficiently wet to give this increment of water vapour. At the latter point the observations on the 29th of October showed a precisely similar water content, viz., 6.2 grains, though the air was 1 degree colder; and on the same date at the place where the shot was fired the air was also 1 degree colder and the water content 5 grains; at the same place on the 9th of November the temperature was the same,

but the water content was increased to 5.8 grains, or within 0.2 grains of complete saturation. On the Stable way, where Bloomfield was killed (Fig. 1), the temperature was 62⅓ degrees, and the air completely saturated with 6.3 grains of water per cubic foot of air; and yet in spite of this saturation, and the wet state of parts of the roadway, Bloomfield's body was certified by the doctor to have been singed, though the pony

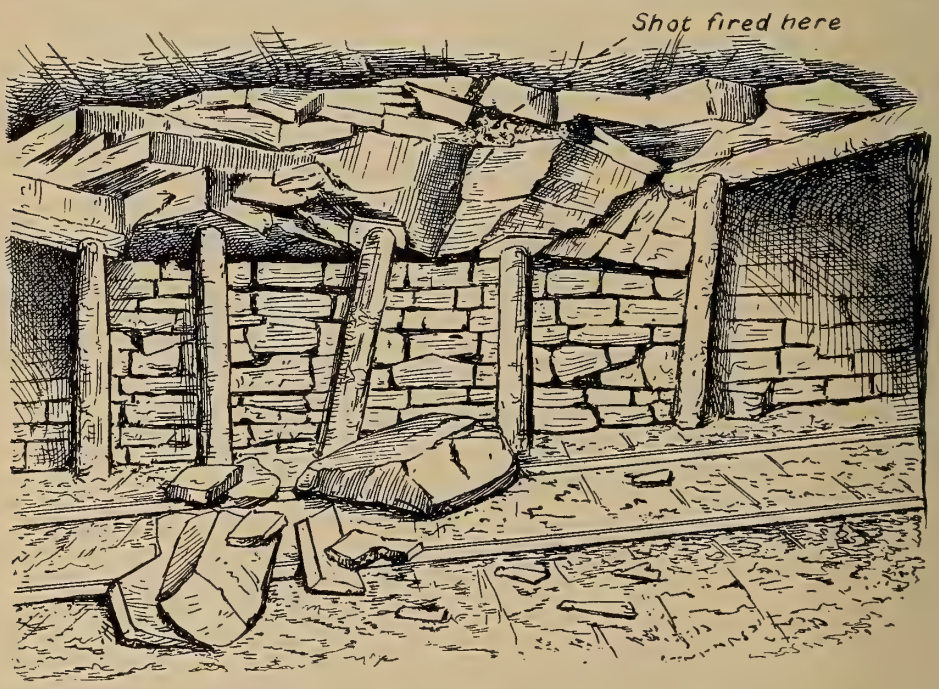


FIG. 5.—WINGATE GRANGE COLLIERY EXPLOSION. SKETCH OF THE PLACE WHERE THE SHOT WAS FIRED WHICH IGNITED THE DUST

killed at the same place was not singed, and the sole case of undoubted burning was that of Maddison at the point of origin of the explosion. From the shot to the shaft the deposit of coked dust was very meagre, but from the same point in by and mostly near to the Second East, the deposits of coked dust were abundant. This is therefore a very remarkable phenomena, viz., that at the point where the air was saturated with moisture, and the deposit of coal dust was getting so small as to bring the explosion to a conclusion, the coking was the most pronounced, thus proving that the flame must have had the highest temperature at this point. Something more than the supposed absence of a sufficient quantity of dust must therefore be looked for to account for the flame not travelling along the Second East way. In a similar way to what occurred at Altofts and Blackwell, the flame of the explosion turned at an acute angle down the Stable way on the west, and up the Drop pit to the Main coal on the east side. The greatest evidence of force was exhibited between the downcast shaft and the top of the Stable way, but how much of this, and the scalding or singeing of Bloomfield, and the production of carbon monoxide, was attributable to the heat and velocity of the escaping steam from the broken pipes, is not stated in the reports. The total volume of afterdamp appears to have been very small, as the men attempt-

ing to escape from the Low Main had evidently traveled long distances before succumbing in the North East way, and a less hurried escape would undoubtedly have saved their lives.

As to the character of the dust, the report says, "that of the four seams of coal worked, the coal from the Harvey seam was of the softest nature, and could be described as the most likely to produce dust." A sample of the Harvey dust collected from the timber in the engine plane and analyzed by Professor Bedson, showed moisture, 2.05 per cent.; fixed carbon, 50.37 per cent.; volatile matter, 27.83 per cent.; ash, 19.75 per cent., and the ratio of fixed carbon to volatile matter, 1.81. From the list of analyses the above cannot be actually compared with the dust from the Low Main seam, and only with a sample of coked dust collected from a prop near the end of the explosion in the North district, viz., moisture, 1.74 per cent.; fixed carbon, 50.54 per cent.; volatile matter, 20.77 per cent.; ash, 26.95 per cent., and the ratio of fixed carbon to volatile matter, 2.43. Assuming that the conclusions were correct that "the supply of dust ceased near the curve to the east, and that there was not sufficient dust to carry flame up the First East way, we are driven to the conclusion that a main haulage road as damp as the First and Second East ways, and with dust of a similar character to that of the Low Main, will not aid the extension of an explosion, and in fact will bring an explosion to an end."

If this demonstration of the effect of a considerable initial flame on coal dust of the character of that met with in the Low Main seam, and in an atmosphere of the same humidity was a positive fact, we should then have a standard with which to compare other explosions, and a *certain* proof that the coal dust was sufficiently watered when the air showed a water content of 6 grains per cubic foot, and that the mine could not have been in a much safer condition. But we cannot accept this proof with our present knowledge and jump to a conclusion, because a comparison of the analyses with those of Camerton, Timsbury and Courrières, etc., testifies that in no case at Wingate Grange did the percentage of ash exceed 44.14, and the ratio of fixed carbon to volatile matter was favourable, viz., 0.89.

The Wingate Grange explosion demonstrated in an unusually practical manner the truth and value of one part of Prof. H. B. Dixon's experiments when he ascertained the rate of explosion of mixtures, aids an explosion, and that steam alone can add this or any larger percentage, and thus retard an explosion. In all probability it was the steam escaping from the broken pipes in the downcast shaft which saved the lower seams of coal from participation in the disaster, in a similar way to what took place at Elemeore, where, under like conditions, an explosion caused by a shot in a top mine was communicated, by means of the downcast shaft, to the lower mines.

The greasy road dirt used by Maddison to cover the charge of geloxite was probably the principal factor which caused the misuse of the explosive to develop into a coal-dust explosion, because of the large volume of flame which resulted from its instantaneous ignition. A similar use of greasy dirt stemming on a road where there was no great quantity of coal dust, was the main initiatory cause of the Timsbury explosion, and an excess of dust brought that explosion to an end on the driest and dustiest road of the colliery.

What were the influences which caused the flame and coking effects to come to a conclusion in the North East way, between Nos. 1 and 2 East ways, and just where the heat appears to have been the greatest, is a problem which does not admit of ready solution, but one part of the solution may with some certainty be attributed to the action of the escaping steam in the shaft which, exerting its force and velocity in a similar way to that

of steam in an injector or a forced blast, reversed the Low Main intake air current, and thus negatived the advancing flame and extinguished it, and at the same time cleared the Second East way from the products of combustion, and thus also produced a safe atmosphere for the men to travel in when escaping from that district until they reached the vicinity of the shot, where the air was stagnated by the blown-out stoppings, etc., and by the destruction of the air casing in the upcast shaft.

The practical lessons to be learned from this explosion appear to be, that air saturated with moisture is no deterrent to the spread of an explosion; secondly, that wet zones of 40 yards long are also of no deterrent value; thirdly, that coal dust in an atmosphere saturated to its fullest limit with moisture may yet be of sufficient dryness as to allow of the accumulation of dry coal dust (as stated by the inspectors); fourthly, that no mine in which fine dust is produced is any safer than Wingate Grange if shot-firing is permitted on the main haulage ways; fifthly, that it is impossible to remove all the dust from the haulage ways of collieries, and therefore the best means to control or prevent the extension of coal-dust explosions, when once initiated, is not only an unsolved problem, but its solution is as far off as ever if blasting is permitted.

WHEEL-LOADS AND RAIL-WEIGHTS

By George Sherwood Hodgins

In considering the various questions which have arisen during the past few years concerning safety and speed in railway service the important matter of increasing wheel loads should not be overlooked. During the past twenty years there has been a steady increase in the loads upon the driving wheels of locomotives, while at the same time the greater frequency of trains has added to the number of times the rails are subjected to deflection and hammer-blow. Mr. Hodgins discusses this important feature in the railroad problem as it has developed in the United States, and he shows very clearly how the weight and section of the rail has been increased to meet the demands upon it. A comparison of the rise and fall of the successive rail sections during the last twenty years with the development of the locomotive itself is most instructive, and its presentation here is an interesting contribution to the subject of railroad construction and operation.—The Editor.

THE rise of the tide upon the seashore, while gradual and steady as a whole, is subject to the fluctuations of wave inflow and subsidence, so that the actual line of advance is nowhere definitely marked at any particular moment. In glancing briefly at the gradual increase of locomotive wheel loads, and the growth of rail sections and weights, one may see a partial analogy in the observed movement of the tide. The advance has been steady, but the onward sweep of progress in this respect has had its local ebbs and flows, like the breakers on the beach.

It is somewhat misleading to say that the increase of locomotive wheel loads has been followed by the growth of rail sections used throughout the country. The fact appears to be rather, that heavier wheel loads demanded heavier rails, and the use of heavier rails paved the way for a still further advance in wheel loads. There has been a kind of inter-relation between the two in which the advance of one depended upon the progress of the other.

Perhaps the most complete record of rail growth to be found anywhere, is that given by Dr. P. H. Dudley, of the New York Central Railroad, in his admirable series of "Condensed Diagrams of Track Inspection" on that road, from 1881 to 1906, inclusive. In referring to this road it seems fair to assume that what has been done by this company has practically been done by others, though probably not to the same extent, and that in a broad sense the work of the New York Central is one of the signs of the times.

In 1881 the whole of that road was laid with 4 and 4½-inch 65-pound rails, and at that time there was an average locomotive driving wheel load of between 11,000 and 12,000 pounds, the type of engine being the standard eight-wheel, or 4-4-0 type. This 65-pound rail, Fig. 1, did not provide very smooth riding, even under the wheel loads of that day. The rails were slightly deflected under the wheel contacts, the metal in the heads being in compression and that in the base, under the wheels, was in tension. Between the wheels the stresses in the rails were reversed, the head being in tension and the base in compression, while the rails tended to act independently of each other, and considerable depression at each joint was the result.

A locomotive standing on such track rested in a number of small depressions, equal to the number of its wheels and proportional to the load on each, just as one might see with a microscope, the surface film of a liquid slightly depressed under each foot of a water-spider. Forcing a locomotive to move along over track composed of such rails consumed a certain amount of power. Part of its

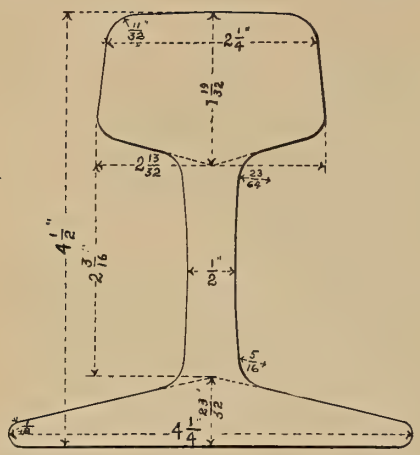


FIG. 1.—NEW YORK CENTRAL RAIL. 65-LB., 4½-INCH. 1881

energy was necessarily employed in depressing the rail, and at each joint the engine had a minute hill to climb.

In 1884 the 5-inch 80-pound rail designed by Dr. Dudley made its appearance on the New York Central. This rail had an increase of 23 per cent. of metal, and a gain of 62½ per cent. in mechanical stiffness was secured. The wheel loads at this period were practically those of 1881, but the reduction of rail depression under the wheels and the stiffer joints not only produced smooth riding, but enabled more of the locomotive power to be transformed into useful work, and at the same time track maintenance charges were reduced. The increased first cost of the heavier rail was offset by the greater volume of business which it enabled the railroad to do. In fact, the new rail was analogous to the increase of capacity of a manufacturing establishment. This enlarged capacity was secured to the railroad without alteration in motive power, rolling stock or roadbed.

The 5-inch 80-pound rail was designed so that it had wider head. This was done in order to obtain practically the same amount of wheel bearing which the lighter and narrower rail had provided by reason of its minute deflection under the wheel. The new rail acted more as a continuous girder than its predecessor, and the joints were much more firm. This rail was also less likely to turn over under a side thrust than the 65-pound rail had been, not only on account of its wider base, but because, with its wider head, it could not roll over without exerting a greater lifting effort on the wheel. The load it carried helped to keep it upright.

The results gained by the use of this pioneer heavy rail demonstrated the important fact that, other things being equal, smooth riding is economical riding both for passengers and freight, and the railroad world began to apply the lesson. The advent and the growing use of this rail with its attendant benefits, invited, as a natural consequence, the increase of wheel loads as the volume of traffic increased. The average driving wheel loads, therefore, ran steadily up to nearly 14,000 pounds in 1890, when 46 per cent. of the road was laid with the heavier form of rail. The increased driving wheel loads actually produced less wear on the 80-pound rail than the lighter loads had produced on the 65-pound rail of 1881, and less destructive shocks were experienced by the rolling stock.

Another factor which exerts considerable influence on the life of rails is the fact that the locomotive is a motor, driven by reciprocating ma-

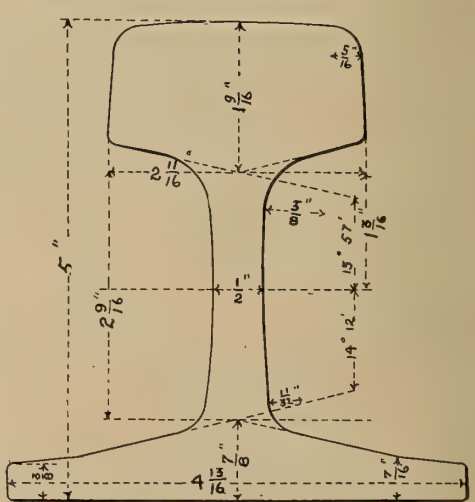


FIG. 2.—PIONEER 80-LB. RAIL. DUDLEY SECTION. 5-INCH. NEW YORK CENTRAL R.R. 1883

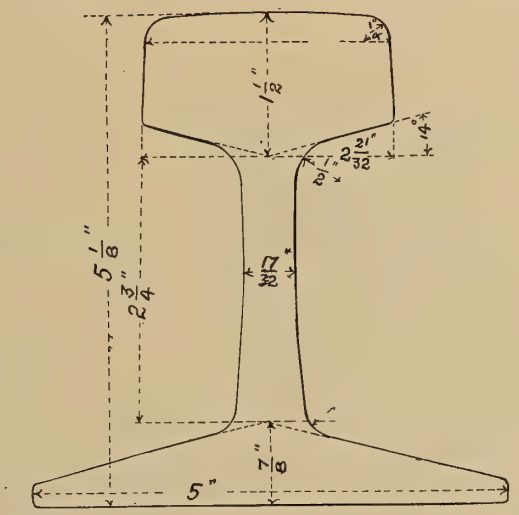


FIG. 3.—NEW YORK CENTRAL R.R. DUDLEY 80-LB., 5⅛-INCH RAIL. 1892

chinery. At two points in the revolution of the driving wheel, maximum stresses are reached, due to the pull down and push up of the connecting rod. At these points the load borne by the rail is greater than the actual wheel load, and the action of the counterbalance weights do not entirely eliminate the result of the angular pull and thrust of the rod.

The area of contact between wheel and rail is necessarily small, and any load resting on a set of wheels is in an exceedingly concentrated form. In fact, for the ordinary style of railroad track, wheel spacing is the measure of load distribution and is quite as important as the number of ties under a rail. The necessity for looking to the wheel arrangement of motive

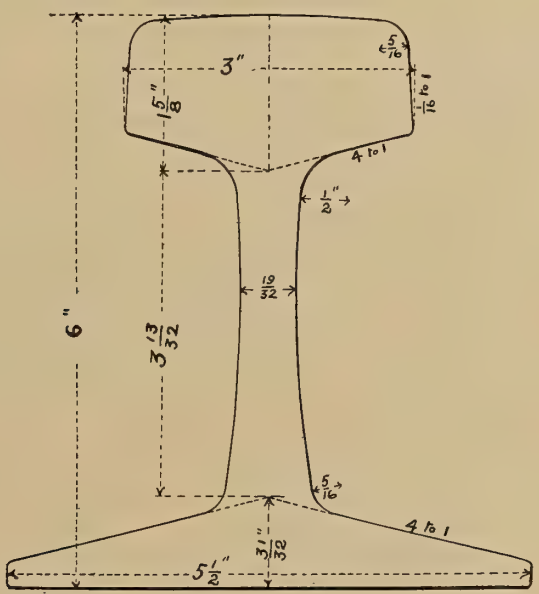


FIG. 4.—NEW YORK CENTRAL R.R. DUDLEY RAIL SECTION. 100-LB., 6-INCH. 1892

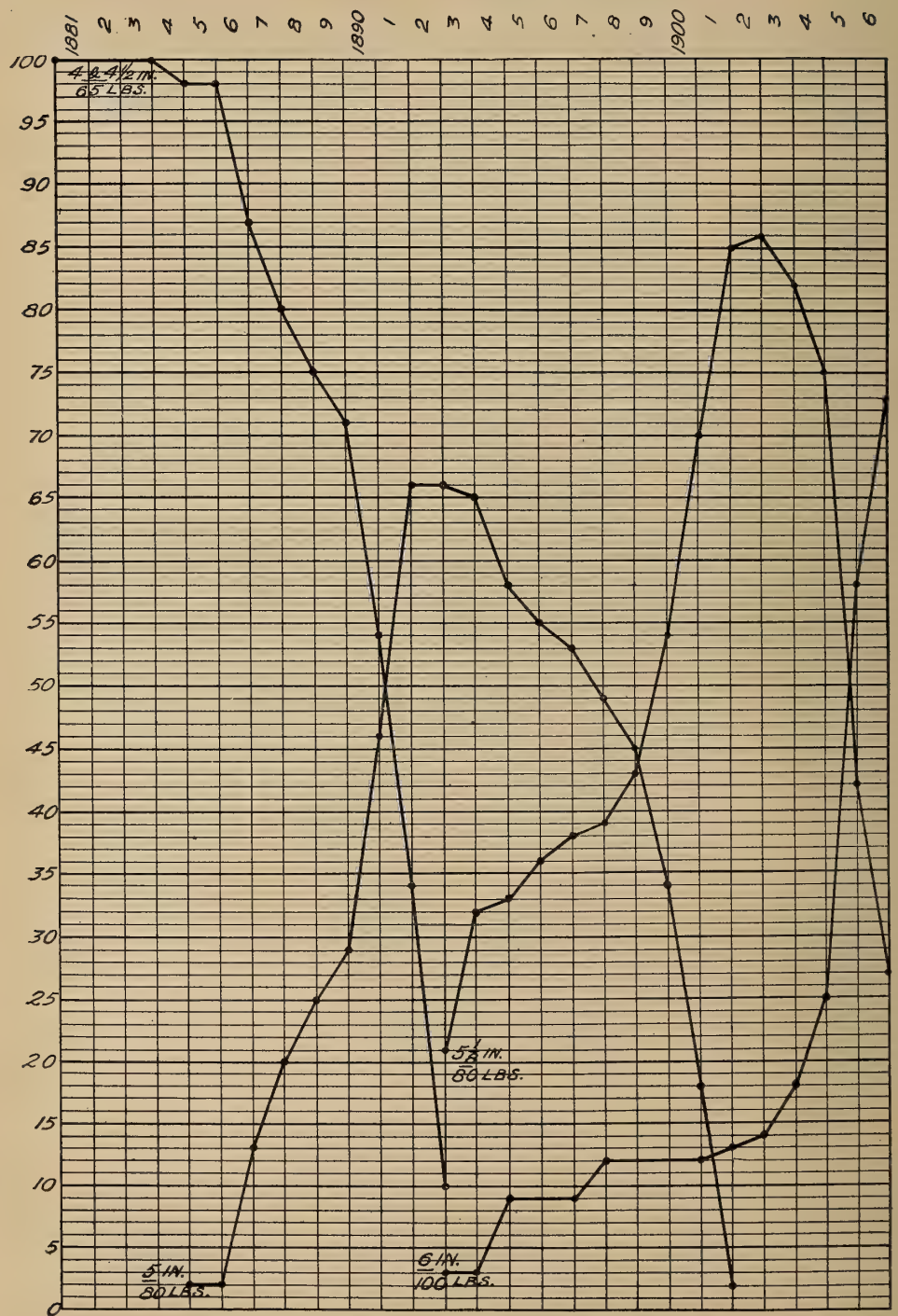


FIG. 5.—DIAGRAM SHOWING THE INCREASE IN WEIGHTS AND DEPTHS OF RAILS IN THE UNITED STATES FROM 1881 TO 1906. THE ORDINATES REPRESENT THE PERCENTAGES OF THE SEVERAL RAILS IN USE AT THE VARIOUS DATES GIVEN ABOVE

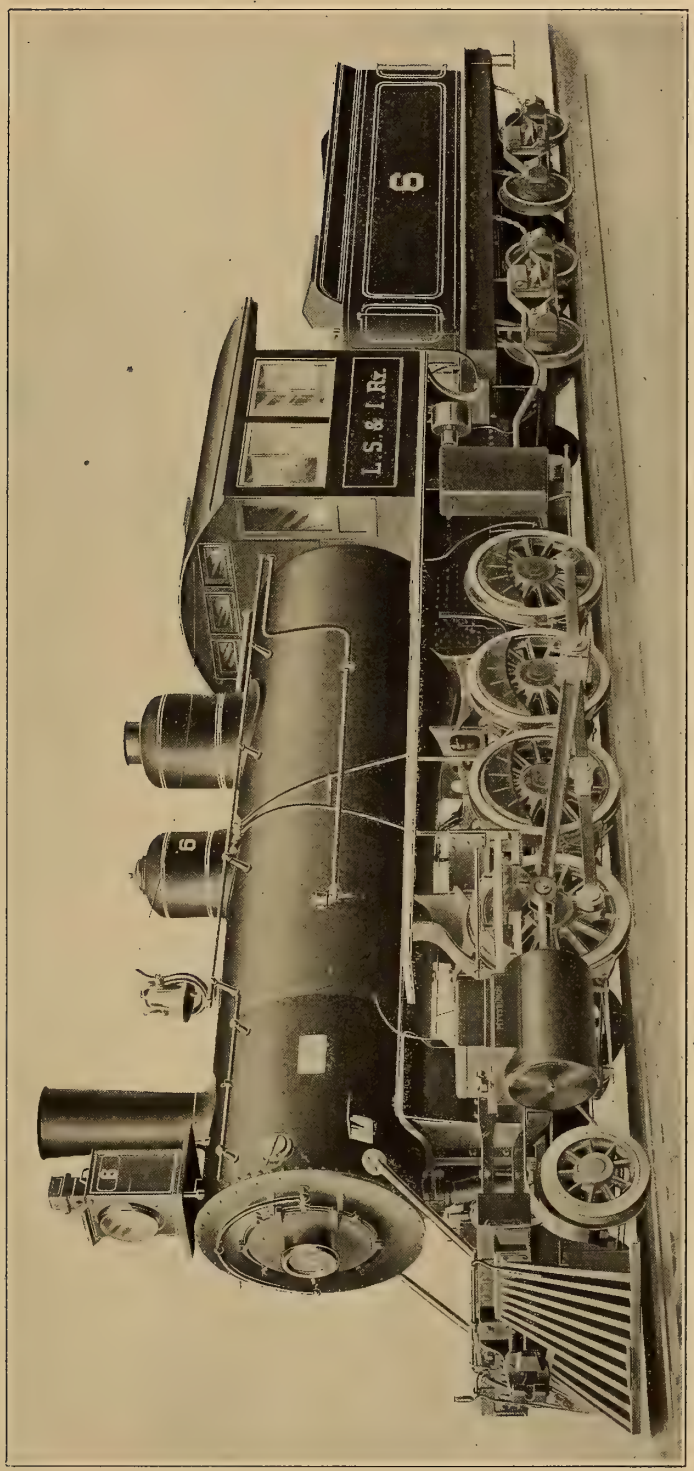


FIG. 6.—CONSOLIDATION (2–8–0) LOCOMOTIVE OF 1896. LAKE SUPERIOR AND ISHPEMING RAILWAY. AMERICAN LOCOMOTIVE COMPANY. TOTAL WEIGHT, 141,500 POUNDS. WEIGHT ON DRIVING WHEELS, 129,000 POUNDS

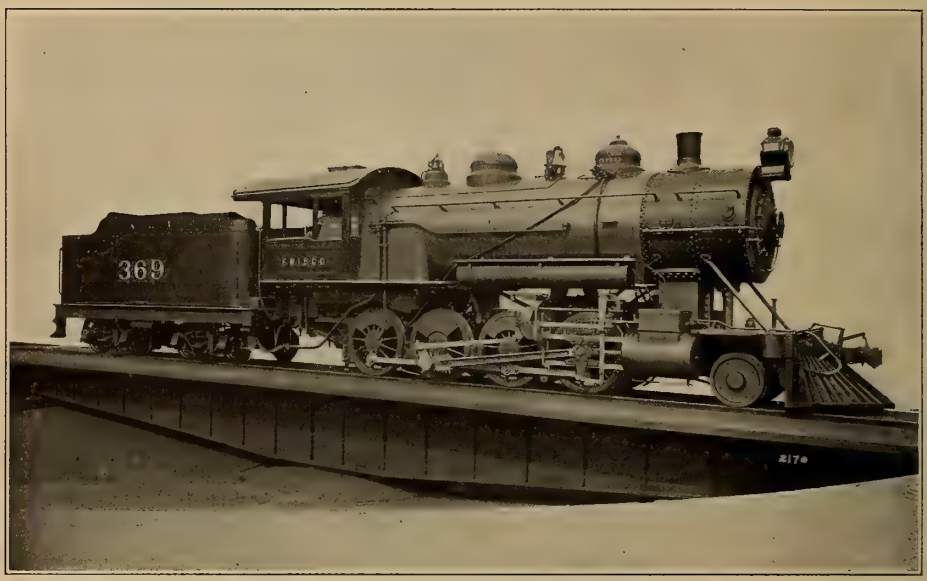


FIG. 7.—CONSOLIDATION (2–8–0) LOCOMOTIVE BUILT BY THE BALDWIN LOCOMOTIVE WORKS. CHICAGO AND EASTERN ILLINOIS R.R. TOTAL WEIGHT, 173,160 POUNDS; 158,560 POUNDS ON DRIVERS

power is responsible for the introduction of the various types of locomotives which are in use on our railways at the present time. The rail has played a most important part in the production of this change.

The earlier conceptions of track construction included the idea that perfect rigidity meant perfect smoothness of motion, but as the value of the various factors entering into the problem came to be better understood, it was found that a certain degree of flexibility, or rather of elasticity, in the track was not only desirable but necessary, both for the maintenance of the roadway itself, but was beneficial for the vehicles which passed over it.

The year 1892 saw the advent of the $5\frac{1}{8}$-inch 80-pound rail on the New York Central, and also that of the 6-inch 100-pound rail, both of Dudley section, with average driving wheel loads but slightly higher than those of 1900. This year, 1892, also marks the maximum use of the 5-inch 80-pound rail, and the "flow" in the use of the $5\frac{1}{8}$-inch rail is concurrent with the "ebb" of the slightly smaller rail. By the year 1896 the 5-inch 80-pound rail had declined to 53 per cent., the $5\frac{1}{8}$-inch 80-pound rail had increased to 38 per cent., and the 100-pound rail to 9 per cent.

A typical consolidation, or 2-8-0 engine, built in 1896, is shown in Fig. 6. This engine was turned out by the American Locomotive Company for the Lake Superior & Ishpeming Railway. The total engine weight is 141,500 pounds, of which 129,000 pounds rest on the driving wheels. This gives a driving wheel load of 16,125 pounds. The cylinders are 20 × 26 inches and the driving wheels are 50 inches in diameter. The rigid wheel base is 14 feet. This engine is capable of exerting a tractive effort of 318,00 pounds. Another example of a somewhat similar engine is that shown in Fig. 7. It is a Baldwin consolidation, for the Chicago & Eastern Illinois Railroad. The total weight is 173,160 pounds, with 158,560 pounds on the drivers, thus giving a driving wheel load of 19,820 pounds. This engine has cylinders 21 × 28 inches, 55-inch drivers, a rigid wheel base of 15 feet 4 inches,

and it can exert a tractive power of about 38,100 pounds.

In 1898-9 the 5 and the $5\frac{1}{8}$-inch 80-pound rails were used on the New York Central in nearly equal proportions, while the 100-pound rail had only increased up to 12 per cent. The $5\frac{1}{8}$-inch 80-pound rail gradually displaced the 5-inch 80-pound rail until, in 1902, there was none of the latter on the road. From 1896 to 1906 the volume of traffic had more than doubled, the proportion of tons hauled 1 mile being as 41 is to 96, or an increase of 134 per cent. In 1896 the use of the 100-pound rail had mounted to 73 per cent.

The average driving wheel load, as deduced from an interesting set of diagrams recently prepared by Mr. H. V. Willie, of the Baldwin Locomotive Works, is seen to have increased from about 11,000 pounds in 1885 to 13,750 pounds in 1890, and for the period between 1885 and 1905 one might say with a fair degree of accuracy that the average increase of driving wheel loads had been at about the rate of 2,700 pounds in every five years. The average in 1907 being about 22,750 pounds.

A good example of the 1906-7 class of consolidation engines which go slightly over the tabulated average of driving wheel loads is the 2-8-0 type built by the Baldwin Locomotive Works for the Western Pacific Railway. This engine, Fig. 5, has cylinders 22 × 30 inches, driving wheels 57 inches in diameter, a rigid wheel base of 15 feet 8 inches, and a total weight of 201,330 pounds. The driving wheels carry 186,330 pounds, which gives a wheel load of 23,291 pounds. The tractive effort of this engine is about 43,100 pounds. Another interesting example, Fig. 6. is that of a consolidation type of engine built by the American Locomotive Company for the New York Central. This one is very close to the tabulated maximum wheel loads of the present day. The total weight of this machine is 226,000 pounds, and the weight on its driving wheels about equals the total weight of the engine shown in Fig. 5. The New York Central consolidation has 201,000 pounds on its drivers, which gives a wheel load of 25,125 pounds. The tabulated maximum for 1907 being 26,700 pounds. The cylinders are 23 × 32 inches, the drivers measure 63 inches in diameter, the rigid wheel base is 17 feet 6 inches, and the tractive effort amounts to 45,700 pounds.

An interesting comparison may be made of the two latest examples of heaviest type of engines which are the product of present day conditions.

FIG. 8.—CONSOLIDATION (2–8–0) LOCOMOTIVE FOR THE WESTERN PACIFIC RAILWAY. . BALDWIN LOCOMOTIVE WORKS. TOTAL WEIGHT, 201,380 POUNDS; 186,330 POUNDS ON DRIVERS

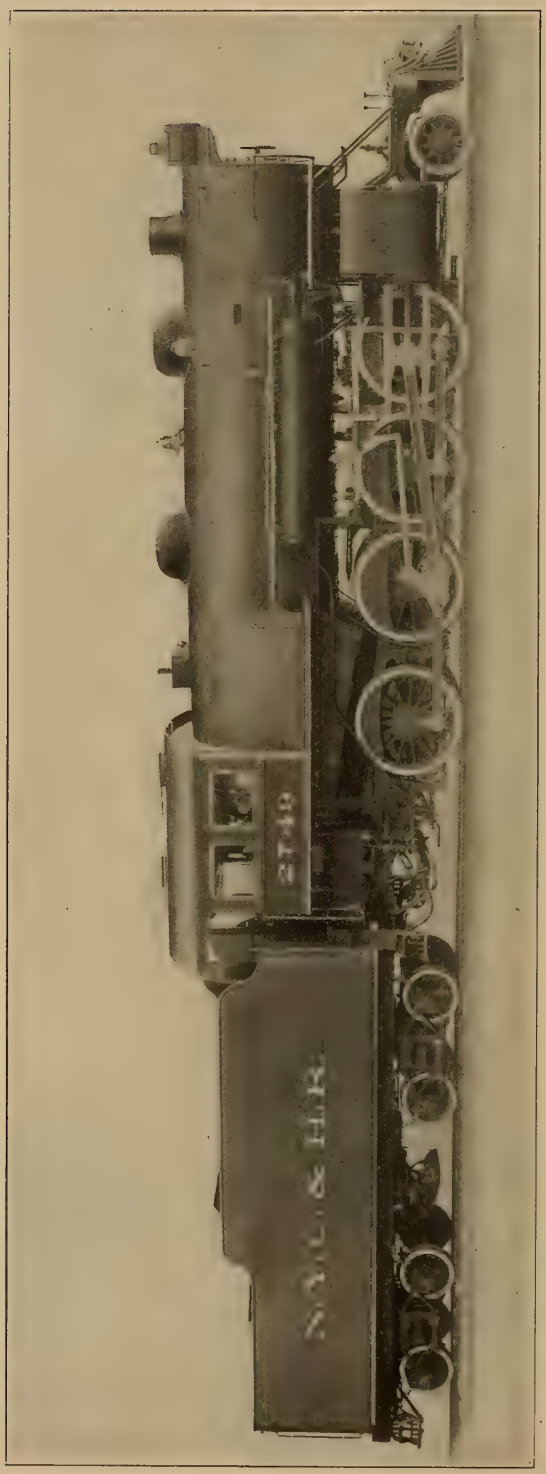


FIG. 9.—CONSOLIDATION ENGINE BUILT BY AMERICAN LOCOMOTIVE COMPANY FOR THE NEW YORK CENTRAL R.R. WEIGHT ON DRIVERS, 201,000 POUNDS

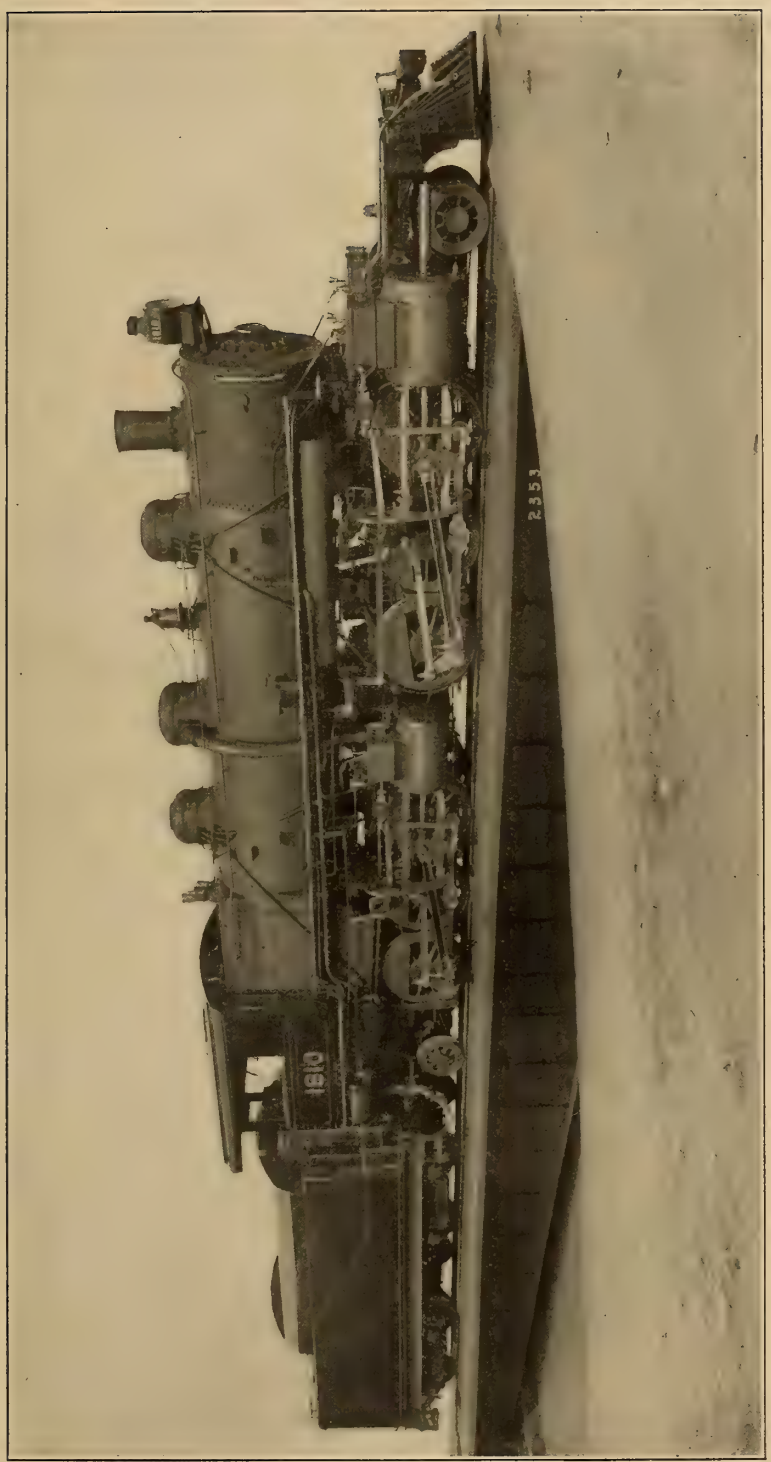


FIG. 10.—MALLET COMPOUND ENGINE FOR GREAT NORTHERN RAILWAY. BALDWIN LOCOMOTIVE WORKS. TOTAL WEIGHT, 302,650 POUNDS; 263,350 POUNDS ON DRIVERS

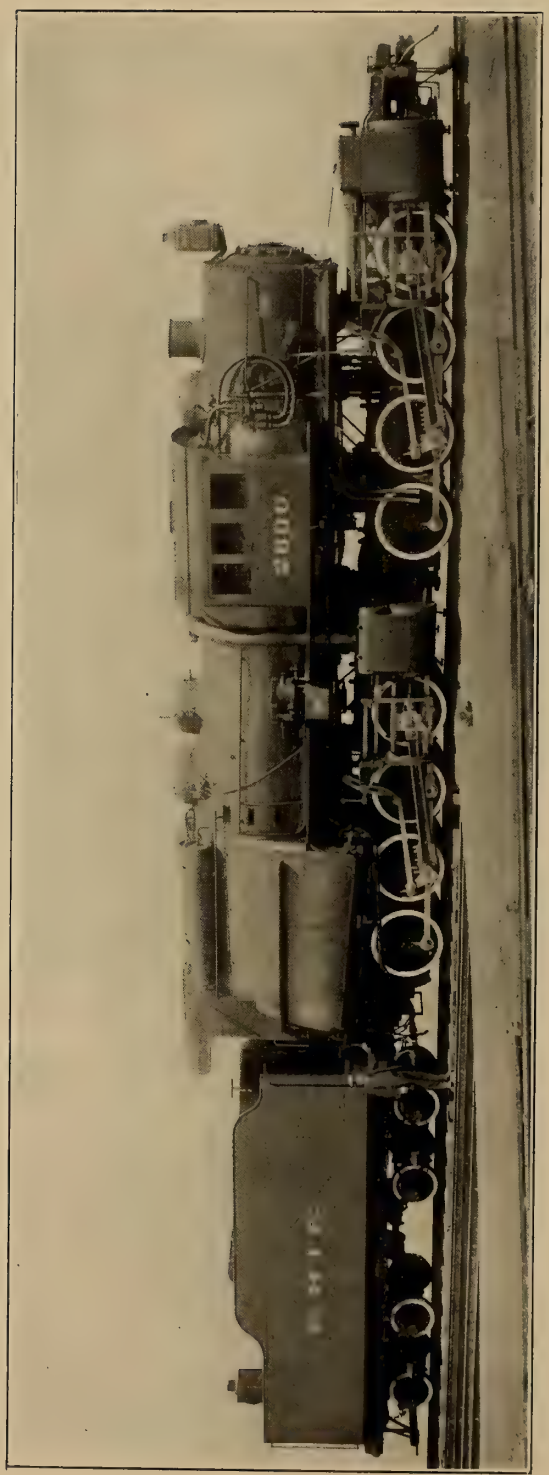


FIG. 11.— MALLET COMPOUND LOCOMOTIVE FOR ERIE R.R. AMERICAN LOCOMOTIVE COMPANY. TOTAL WEIGHT ON DRIVERS, 409,000 POUNDS

These engines are of the Mallet articulated compound type, and one of them was recently built by the Baldwin Locomotive Works for the Great Northern Railway, Fig. 7. It has six pairs of driving wheels 55 inches in diameter, and there is a leading and a trailing truck. The total weight of the engine is 302,650 pounds. The twelve driving wheels carry a total weight of 263,350 pounds, which gives a wheel load of 21,945 pounds, which is only slightly above the present day average. The tractive power of this engine is 61,000 pounds when working compound. The wheel base of each group of driving wheels is 9 feet 10 inches, and the total driving wheel base is 28 feet 11 inches. The Mallet articulated compound, Fig. 8, built last August by the American Locomotive Company for the Erie Railroad, is the heaviest engine so far constructed. It is more than twice as heavy as the New York Central consolidation shown in Fig. 6, and nearly three times the total weight of the Lake Superior & Ishpeming engine shown in Fig. 3, being 409,000 pounds in weight. The wheel load is therefore 25,562 pounds, being practically the maximum wheel load so far attained. The drivers are 51 inches in diameter, each group has a wheel base of 14 feet 3 inches, with a total wheel base of 39 feet 2 inches. The tractive effort of this engine, working simple, is 94,800 pounds.

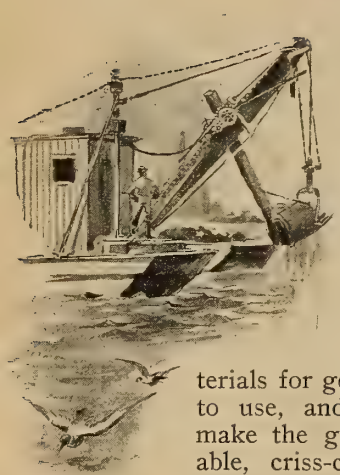
When the various conditions which prevail in railroad operation are considered, it becomes clear that the form and weight of the rail has not been solely the result of the increase in wheel loads. The weaker or limber rail, in the phraseology of the prize ring, not only received severe punishment, which produced more or less rapid deterioration of the track, but it used up part of the energy of the locomotive which could have been more profitably employed in economically hauling the paying load. It also caused more or less destructive shocks to the rolling stock. The better design of rail and its greater enduring qualities makes for a lower cost of operation, which in a prosperous country tends to augment the volume of traffic. This in turn reacts on the design of engines and cars in the direction of increased capacity, and this being accomplished, the rail is taxed to stand up to the heavier work which its own efficiency was an important factor in producing.

Smooth track and heavy rails invite fast speed, and the mechanical engineer increases his boiler and perhaps increases the diameter of his driving wheels. The master car builder increases the capacity of his cars, and the effect is soon noticed in the maintenance of track. The volume of traffic which has grown up is there to be handled, and conditions are gradually readjusted. While loads have been maintained or slowly increased, the careful redistribution of weights and a modification of locomotive wheel arrangements is resorted to. The increased proportion of paying load to dead weight of car introduces new designs, but holds down the wheel load within reasonable limits, while the earning power of each vehicle is enhanced, and the gradual, though steady, increase of rail section and weights completes the cycle.

All through the progress of railroad operation the close inter-relation of rail weight and wheel load is apparent. There are many slight advances and retrogressions, which throw a temporary measure of advantage, now to one department and again to another. It is, however, the algebraic sum of these small plus and minus quantities which gives the total of the advance made. There is no hostile rivalry on either side. Wheel and rail interact in a sort of team play. They work together in the same field and always toward the same goal.

THE REVIVAL OF INTERNAL WATERWAYS IN THE UNITED STATES

By George Ethelbert Walsh



NATURE in fashioning the map of North America strung a series of unsurpassed harbors and coves along both of its lengthy seacoasts, filled the forests, mines and soil with precious raw materials for generations of men to use, and then, as if to make the gift more serviceable, criss-crossed the land with rivers, cutting the whole hemisphere practically in half, and chopping up the remainder in divisions and sub-divisions by lesser streams. The early settlers found almost uninterupted water routes from the Great Lakes to the Atlantic Ocean on the east and to the Gulf of Mexico on the south. For thousands of miles their tiny canoes could paddle their way up sun-lit rivers, exploring great alluvial districts and rich farming lands, passing through impenetrable tangles of giant forests, and navigating deep canyons and narrow mountain defiles which the erosion of the streams had for aeons of years cut out. The furs of the great northern country were floated down lake and river to distant seaports; lumber from the endless forest lands were rafted by several routes to the ocean, and flotillas of dugouts and flat-bottom boats freighted the products of farm and mine to either coast. These great natural highways became regularly established trade routes long before the whistle of the steam engine was heard in the land.

Looking back a century or two the question of why the natural trade routes were abandoned for the artificial highways created by the genius of man appears somewhat puzzling. In the early days of settlement the work of making the inland and coast waterways permanent by improvement was carried on energetically. From the canoe and dugout the river craft quickly developed into the flat-bottom freighters propelled by long poles and huge oars, and these in turn made way for the early types of river steamboats, with their great freight-carrying capacity and insatiable appetite for consuming cord-wood. The Ohio and the Mississippi became the great commercial highways of the interior, and on their bosoms floated the wealth and products of half the country.

Canal projects early formed in the minds of the pioneer settlers. The Pilgrim fathers, as far back as 1630, seriously considered cutting a canal across Cape Cod, to facilitate trade with the West, as New York was known then to the New England residents. In Washington's day the canal through the Dismal Swamp, which has since become an important link in the proposed inland waterway for sea-going barges from New York to Florida, was commenced and carried forward extensively. The Chesapeake and Delaware Canal, completed in 1829, at a cost of $2,250,000, was long under consideration, and was a matter of speculation a century before its building. Likewise, the Erie Canal and its tributaries were dis-

cussed as a possible project decades before the first spadeful of dirt was taken from its bed. In the West, rumors for improving the great natural arteries of travel by digging short-cut canals were matters of common concern and interest. The pioneers lacked only the facilities and capital for entering upon an era of canal digging that would have made the history of early development of the country somewhat different from what it has been.

River traffic was at its height when the first canals were planned and completed. The competition of the railroad was not then seriously considered. The natural movement of traffic seemed ordained to follow the great inland waterways created by a beneficient providence. The tributes of a nation could follow the streams to the ocean, and the cheapest way around was to send freight by boat down the mighty rivers to their mouths. The canal was considered as a means for shortening the route or for connecting two or more prominent streams.

The advent of the railroad marked the dawning of a change in methods of transportation. At first the railroads were not seriously concerned with the development of the inland waterways. They reached across the continent, or crossed State lines to connect prosperous inland towns with the seaboard, and brought promising industrial and agricultural sections into new life. The river-traffic fed the railroads and added to their prosperity. There grew up a great industrial traffic through the co-operation of river, canal, and steam road, and the phenomenal development of the country was due equally to these three methods of transportation.

How then did the present blight of canal and river spread over the country, and practically paralyze transportation by inland water routes? Why did the properous boat-traffic of the Mississippi decline, and the Erie and other canals fall into almost general disuse? A period of lethargy in inland water traffic followed, so that expensive canal and river improvements were allowed to go to waste. With but few exceptions the canals on which small boats were drawn by horses and mules were abandoned. In 1895 the total mileage of canals in operation was only 2,400 out of a total mileage of 4,000. In that year 238 miles of the operated canals, representing two canals which had cost $12,663,095, were recommended for abandonment.

The decline in the canal and river traffic was due to the powerful influence of the railroads, which had grown enormously in twenty-five years, while inland water transportation remained stationary. The capital required to build the railroads absorbed the energies and resources of the nation. With the increase in competition, the railroads sought to parallel the existing water-ways, and to accomplish this successfully State and Federal aid was invoked. The impression was industriously spread abroad that the canals were antiquated institutions and not adapted to modern business methods. Railroad transportation was the only quick and profitable method of moving the country's freight, and investments in canals and water routes would would never pay. This doctrine, so adroitly fostered by the railroads, spread with amazing rapidity. The Erie Canal, with its capacity for carrying 100 ton boats only, felt the blighting effect, and any attempt to enlarge and improve it was met by hostile influences at the State capital. The Delaware and Raritan Canal became practically a worthless water route, and under the power of the railroads it has remained up to the present an insignificant factor in industrial development. In spite of the effort of the railroads to kill the canals, the Erie still retained its usefulness. Under the serious handicap of inadequate size and construction its tonnage from 1884 to 1887 averaged over 5,000,000 tons annually. It was this good showing that induced the

legislature to pass in 1887 an appropriation bill of $550,000 to double the capacity of the locks, and a similar amount in 1888. From 1836 to 1862 the size of the canal and locks had been improved so that boats carrying 240 tons could be accommodated. But even these improvements were mere drops in the bucket. For every hundred thousand dollars invested in canal or river improvement, the railroads spent millions.

The railroad construction era conferred untold benefit upon the country. It would be a narrow estimate of their value to belittle their achievements. While wasteful practices in individual cases marked the great work, and financial jugglers wrecked many a line, the railroad builders converted an extensive, sparsely settled empire into a fruitful, prosperous country whose abounding possibilities for the future can barely be forecast. The railroads were as essential to our national growth as were the resources locked up in mine, forest and soil. But the mistake was made in stiffling river and canal improvements for greedy, selfish purposes. In order to gain and hold the traffic, the railroads inaugurated a campaign of open hostility to every form of water traffic which in any way interfered with their work. Water competition was as ruthlessly stifled as were smaller steam-road rivals. Each demand for the improvement of the canals by the States or of rivers by the National government was met by powerful lobbyists working in the interests of the railroads. When $9,000,000 were appropriated in 1894 by the New York Legislature to enlarge the Erie Canal to a uniform depth of 7 to 9 feet the cry of "graft" and political debauchery of the people's money filled columns of the newspapers.

But the temper of the people was better understood when the referendum vote was taken in 1905 for expending $101,000,000 on the Erie Canal to enlarge its 440 miles so that thousand-ton barges could be accommodated. This proposition was ridiculed by financiers, railroad corporations, and many commercial bodies. The old argument that canals were antiquated institutions was renewed, and it was said to be a waste of the people's money to make further improvements in the old historic waterway. But the voters expressed their will at the polls, and the Erie is now in a fair way of being brought nearly up to date. Some $20,000,000 of this appropriation have been spent on the canal. When it is finished, vessels drawing eleven and a half feet of water can pass from the Great Lakes to the Atlantic Ocean through the canal, and tows of barges may transport in a single shipment from 12,000 to 15,000 bushels of grain. The present cost of carrying wheat through the canal averages 1.9 mills per ton per mile, while the reports of the principal railroad lines running out of Buffalo show an average cost of 6 mills per ton per mile. With the canal enlarged to accommodate thousand-ton barges, the cargo capacity will be increased four times, and the estimated maximum cost of transportation will be 0.52 of a mill per ton per mile.

The present attitude toward canal and river improvement is diametrically opposite to that which prevailed twenty-five, and even ten years ago. Even bankers and financiers have begun to shift their base. Prior to the present enlargement of the Erie it was almost impossible to interest any private corporation in canal building. There were few capitalists who were willing to invest their money in this class of work. The railroads had controlled the money markets to such an extent that funds which flowed easily into railroad construction were chary of canal building. The sole reliance of the people was therefore on State and National aid. The change had been brought about gradually and as a result of the present inadequacy of transportation facilities the railroads have become congested, freight traffic is blocked, busi-

ness is handicapped, and the whole future prosperity of the country threatened. With James J. Hill's estimate that some 15,000 miles of new track must be built each year for the next five years to catch up with the growth of business, fresh in mind, the outlook for relief from freight congestion is not promising. A thousand million dollars a year invested in new railroad construction would scarcely more than keep pace with the present increase in traffic.

Merchants, commercial bodies and private individuals have thus been forced to turn to the canals and inland waterways for relief. The disastrous result of neglect of these natural highways is now growing apparent. Private corporations are entering into canal construction and river improvement, and the lost commerce of the inland water routes may yet be recovered in the next few decades.

Once more a study of the map will show the generous forethought of nature in criss-crossing the land with rivers, lakes and great arms of the sea. Yet in her endeavor to map out a network of waterways to accommodate the traffic of a great commercial empire, she made some signal failures. Instead of connecting these streams and rivers, these great inland seas and lakes, these giant arms of the sea, by short, cross-cut belts of water, she stopped short of fulfilling her promise in the most tantalizing manner. She brought close together, the great rivers that drain thousands of miles of territory and then switched them off again to flow in opposite directions. In a dozen cases she fell just short of completing a most comprehensive water system for the whole country. Thus the Mississippi through some of its branches runs aggravatingly close to navigable streams which empty into the Atlantic Ocean. The Great Lakes at several points come so ridiculously near to some stream other than the St. Lawrence, that finds its way to the Atlantic seaboard, that one is inclined to be critical of Dame Nature in her fickleness in mapping out the North American continent.

The correction of this natural system of waterways by building short and long canals is one of the stupendous works of the present age. An expenditure of less money than has been invested in American railroads in ten years would bring the water systems up to a comprehensive development so that the traffic could be doubled without further railroad extension. The railroads of the United States are confessedly unable to cope with the problem of transportation at the present rate of increase. To build some 15,000 more miles of new trackage annually for the next five years, to catch up with the growth of business, would entail an expenditure of more than a thousand million dollars a year. In comparison with this estimate of the needs of the railroads, we have the cost of construction of a fifteen-foot channel in the Mississippi from St. Louis to New Orleans placed tentatively at $100,000,000. Such a channel would enable a modern powerful tugboat to haul to seaboard, a tow equal to thirty or forty train loads of freight. This improvement alone would do the service of nearly five thousand miles of new railroads. The enlargement of the Erie Canal at a cost of $101,000,000 will practically permit a traffic in the navigation season greater than a new four-track line from the Great Lakes to the seaboard could handle. The construction of the proposed canal connecting the Ohio River near Pittsburg to Lake Erie, to deflect a part of the commerce of this manufacturing center into the Erie Canal, at an estimated cost of $35,000,000, would prove of more benefit to shippers of heavy freight than a thousand miles of new railroad. Another canal project is to carry out Washington's old plan to connect the Ohio and Potomac rivers so that the Pittsburg factories would have a direct water route to the Atlantic. Toledo and Cincinnati, by the enlargement of the old canal

connecting Lake Erie with the Ohio River, would have a direct water route for small ships and barges to the Great Lakes and the Gulf of Mexico by way of the Mississippi. The cost of these two canals would be less than $80,000,000. Then, too, the enlargement of the Chicago drainage canal at an estimated cost of $31,000,000 would make that city a midway port between the Gulf and Great Lakes, with barges and small ships passing uninterruptedly from one body of water to the other. The construction of the Cape Cod Canal by a private corporation at an expenditure of $10,000,000 is already under way, and it will shorten the distance between Boston and New York by the outside route 120 miles, and by the inside route by 70 miles. As the annual tonnage around Cape Cod is estimated at 30,000,000 the new canal will play a most important part in our eastern commerce.

The inside water route from New York to Florida is another link in the chain of canals to improve the commerce of our seaboard. The proposed ship canal connecting the Delaware and Chesapeake bays will bring Baltimore 250 miles nearer New York, and it will cut down the water route from Philadelphia to Baltimore from 375 miles to less than 100 miles. The estimated cost for this is only $20,000,000. The rest of the canal system along the coast could be built for less than $50,000,000, making it possible for barges and small ships to sail directly from New York to the Chesapeake and the seaports of the southern coasts without venturing outside around the stormy and dangerous capes.

The proposed canal developments and river improvements do not stop at these great schemes. The great Rio Grande drains an immense region in the southwest. By digging a canal near its mouth to the Mississippi, at an estimated cost of $5,000,000, the great navigable rivers of Texas would be connected with those of the Mississippi, the Ohio and the Missouri, making it possible for boats of large cargo-carrying capacity to travel on fresh water some 8,000 miles without interruption.

When we compute the cost of all these canals, and compare the huge sum with that required for extending our railroad systems, to accommodate our increasing traffic, there will be found a large surplus still in favour of the canals. We may even add to these schemes several others which are only tentatively under serious consideration. Any plan that contemplates the construction of canals to connect the great rivers and lakes must take up also the project of dredging the rivers themselves. The deepening and widening of the Mississippi would absorb a round $100,000,000 and more, but this would mean the opening of a great series of smaller waterways to accommodate the traffic of the bordering States. It is conservatively estimated that some $17,000,000,000 have been invested in our railroads. In spite of this enormous sum it has proved profitable to the country and the investors. With an investment of a fraction of this sum in canals and river improvements, there could be opened up a system of water connections to float nearly ten times as much traffic as the railroads now accommodate.

Significant of the impending era of canal building in this country is the appointment of the Inland Waterways Commission by President Roosevelt last April and the comprehensive plans of improvement which the Commission contemplates. Heretofore our appropriations for river and harbor improvements have been of a spasmodic and unrelated nature. There has been little attempt to consider the whole question from the point of view of the greatest benefit to the whole country. Politicians considered their share of the appropriations for rivers and harbors more in the light of favours conferred, under the old spoils system, than as of great public benefit to the commerce of the country.

The Inland Waterways Commission has a momentous task set for it. The members of the Commission are experts in related lines. Gifford Pinchot, the chief forester of the United States, has devoted his life to a study of forest preservation and the influence of our woods on the waterflow of streams and rivers. Brigadier-General Alexander McKenzie, chief of engineers of the army, has spent more than half a century in the enlargement and improvement of our harbors and navigable rivers. Frederick H. Newell, director of the United States Reclamation, has been foremost in controlling the headwaters of our rivers for the purpose of preserving and reclaiming inundated land. Professor W. J. McGee, director of the proposed St. Louis Museum, and leading scientist of the Geological Survey and the Bureau of Ethnology, is an expert in river transportation and management of navigation problems. Senator Newlands, of Nevada, has made an exhaustive study of irrigation, river transportation, and the effect of forests on the volume of streams. Senator Warner, of Missouri, is another expert on these subjects. Former Representative Bankhead, of Alabama, and Representative Burton, of Ohio, held the same position in the House as Senator Newlands did in the Senate in respect to the advocacy of river and lake improvement. Herbert Knox Smith, Commissioner of Corporations, brings legal talent of the highest order to the Commission.

This able Commission will make exhaustive studies of the whole inland waterway problem, and upon their report Congress may be depended upon to pass such laws that will bring system out of the present chaos. The problem of reclaiming the navigable rivers of the United States is too stupendous for private corporations to undertake; but with the rivers once made navigable by the National Government the construction of intersecting canals to shorten routes will be financiered by private corporations. Already a dozen canal companies are in the field making preparations to connect important rivers and lakes with barge canals. Their work is simply waiting upon the action of the National Government in deepening and controlling the great streams which will feed the canals.

One of the first and greatest problems that the Commission will undertake to solve will be the control and deepening of the Mississippi and Missouri rivers. These two enormous waterways are at present a source of enormous loss to the different States through which they flow. Annually they carry into the Gulf of Mexico upward of 400,000,000 tons of floating sediment, which is about twice the amount of material that must be excavated to complete the Panama canal. During the seasons of floods, these two mighty streams overflow their embankments and destroy millions of dollars' worth of property. Yet their control is not an impossible engineering feat, but it must be undertaken on a comprehensive plan. The stream must be checked in its flow in the rainy season at every point of its route and not simply near its mouth. The vast volumes of water, if deflected to canals and great storage basins, could later in the season be utilized for irrigation purposes that would save hundreds of thousands of acres of crops from destruction by the hot, scorching winds of dry summers.

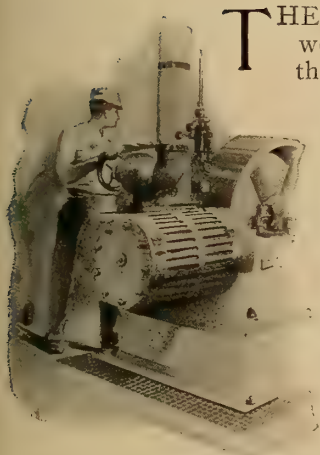
The deepening of the Mississippi and Missouri at their shallowest points, the straightening of the main channel where it crooks and curves around like a snake, and the complete control of its waters at all seasons would prove of enormous benefit to the millions of people living in the great central valley of the country. On the Pacific coast similar flooding of the Sacramento River district has been partly checked, and works for controlling it now under way involve an expenditure of $40,000,000. Before any comprehensive

system of canals can be constructed to accommodate the commerce of the country, the streams must be made navigable and amenable. With the inland waterways once properly developed, the commerce of a large part of the country could double several times over without taxing river transportation to a fraction of its capacity. The railroads have in recent years recognized their inability to catch up with the expanding industrial conditions, and there is less opposition from this quarter to canal or river improvement than ever before in the history of the country.

We thus enter a canal-building era that must have as great an influence upon the industrial life of the future as the railroad building epoch did in the past. The expenditure of hundreds of millions of dollars in inland waterways in the next few decades will make the problem of digging the Panama Canal appear small and unimportant in comparison. Public, private and National capital will be invested in these new trade routes. Great sections of the country, which are now impeded in their development through inadequate transportation facilities, will become industrial centers of vast importance. Mining, agricultural, manufacturing, and industrial life will receive a new impetus, and it is not unlikely that the output will be doubled and trebled within a few years after the system of waterways is completed. The work is one that will require years for its fulfillment, and the best engineering talent of the age will be enlisted in the cause. The railroads of the country were not built in a day, nor a decade; and its canals and navigable rivers cannot be developed to their full capacity in any shorter time.

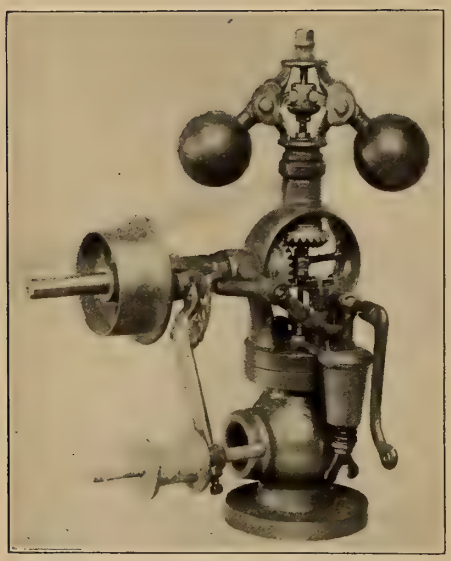
THE SPEED REGULATION OF STEAM ENGINES

By Sterling H. Bunnell



THE first steam engines were designed for the purpose of pumping water from mines and were not provided with any form of speed governor. With the application of engines for power purposes the regulation of speed became important and the fly-ball governor was one of the first accessories invented by James Watt. Together with others of Watt's devices, this type of governor has been in continuous use to the present time. Its operation in connection with the regulation of steam engines was exclusively as a throttling governor, controlling the pressure in the steam pipe, until the discovery of the method of regulating engine power and speed by varying the cut-off. At this point, the ball governor reached its limit, as it has not sufficient power to quickly adjust the movement of slide valves. It remained for the inventor of releasing gear to adapt the ball governor to varying the cut-off, and with this improvement speed regulation of a high degree of accuracy was obtained.

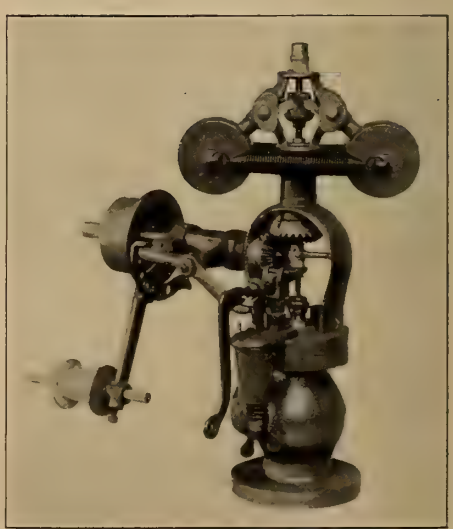
Following Charles T. Porter's high-speed engine, in which the fly-ball governor was used to control the movement of the steam valve by means of a slotted link motion, a number of high-speed engines were brought out by different designers, all embodying some form of variable cut-off produced by means of a slide valve operated by an eccentric of varying throw. Such an eccentric was necessarily controlled by a governor revolving around the engine shaft. The shaft governor as first used consisted of a number of weights pivoted to the arms of the engine fly-wheel, or in a special governor case carried on the main shaft of the engine, with suitable springs to oppose and balance the centrifugal forces of the weights, and proper link connection between links and eccentric. These governors were designed so that the centrifugal forces of the weights at the highest allowable speed of the engine would be just sufficient to stretch out the opposing springs and bring the weights to their extreme outward position, while the links at the same time shifted the eccentric to its inmost position, where it would give the steam valve the least travel and the greatest angular advance. By proper design of springs and weights, a slightly lower speed would cause the weights to move inwards, shifting the eccentric to a position of greater throw. Regulation of the engine by this form of governor could be brought to almost any desired degree of accuracy, it being obviously possible to design springs and weights so that the difference of one revolution per minute or even less in the speed of the engine would cause the weights to move from one extreme position to the other. Attempts to govern thus closely with suddenly varying load resulted in producing "hunting," a mode of action in which the engine runs alternately from too high to too low a speed, a sudden change in load starting a see-saw action between weights



STANDARD FLY-BALL THROTTLING GOVERNOR. JUDSON GOVERNOR CO., ROCHESTER, N. Y.

and springs which is fatal to proper regulation. This can be to some extent checked by dash-pots, but with an increase in complication and liability of derangement.

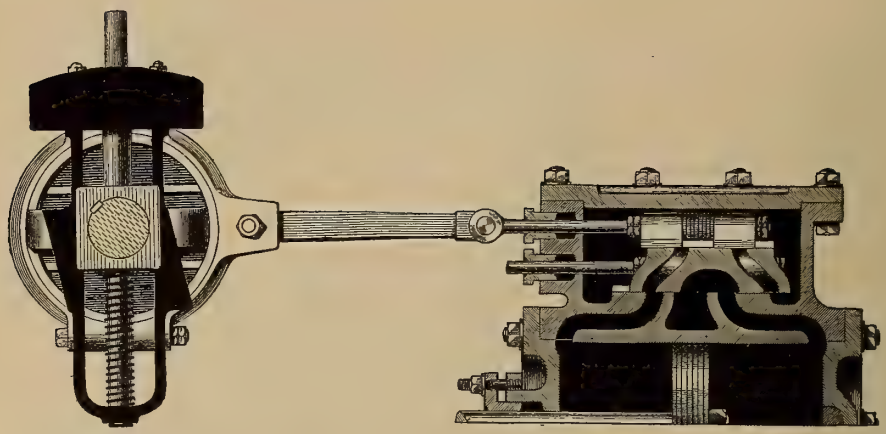
Beside the evident centrifugal action of the weights in a shaft governor, there are other resultant forces which attracted the attention of designers. One of these is the effect of inertia of the revolving weight, causing it to oppose a change in position radially. This in itself exerted a checking effect during sudden changes in load. With the advent of the direct-connected electric generator, and the attempt to handle varying loads and light by incandescent lamps, the regulating conditions became much more severe, and to meet them the well-known inertia governor invented by F. M. Rites was produced. The Rites governor is extremely simple, as it consists of but one elongated weight pivoted near the center of the engine shaft and opposed as to its centrifugal force by a proper spring. The principal part of the mass of this weight arm is situated at the two ends of the arm, and by proper design, the center of gravity of the arm as a whole is brought a short distance from the center of the engine shaft, so that the arm acts centrifugally in the same way as in the earlier forms of shaft governors, and the centrifugal action is opposed by the spring in the usual way. The masses at the ends of the arm, however, act very differently and with great force as required, any sudden decrease in speed of the engine due to an increase in load causing the engine shaft to fall behind the governor arm in angular velocity, so that the arm virtually runs ahead of the wheel and shifts the attached eccentric almost instantaneously. Engines governed in this way are able to maintain an almost uniform speed even under extreme changes of load, it being an easy matter to so adjust an engine with Rites' governor that a load equal to the entire capacity of a generator may be instantaneously cut off by opening a switch, with only a scarcely perceptible increase in the speed of the engine. The hunting action of a Rites governor is very slight compared with that of a centrifugal governor, as the tendency of the governor arm is to check hunting when it occurs, by reason of its extreme quickness in movement.



HIGH-SPEED THROTTLING GOVERNOR WITH SPRINGS TO OPPOSE CENTRIFUGAL FORCE. JUDSON GOVERNOR CO.

PORTER GOVERNOR, WITH KING ELECTRICAL SPEED CONTROLLER, AS APPLIED TO PORTER-ALLEN AND OTHER ENGINES. SOUTHWARK FOUNDRY AND MACHINE CO., PHILADELPHIA

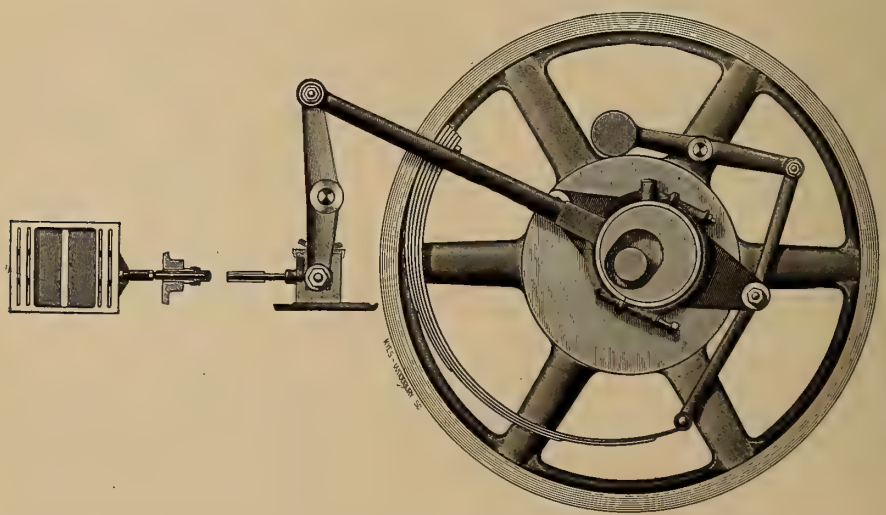
The three forms of governor described are to-day in general use, each having its own field and being preferred for certain conditions. Throttling control, long since abandoned as uneconomical, has in recent years come again into prominence by reason of the discovery of the superheating effect of a throttling valve on the steam passing through it. The Willans central-valve engine, exploited in recent years and used with much success, employed piston valves carried within the hollow piston rods of the engine and driven by eccentrics carried on the main cranks. No form of shaft-governor control was possible with this construction, and the throttling governor was necessarily used as the only possible means of controlling speed. It was found, however, that a power house provided with several units could give good results, as the engines themselves were mechanically very efficient and could be so adjusted that all but one of the engines running at any time would carry practically full load and only one be running under the governor with its steam supply throttled to any great extent, and this one would receive the benefit of the superheating The loss in efficiency of such an engine, if divided among all the en-



AN EARLY SHAFT GOVERNOR, DESIGNED BY ARTHUR RIGG IN 1876. WEIGHT UNBALANCED AGAINST GRAVITY

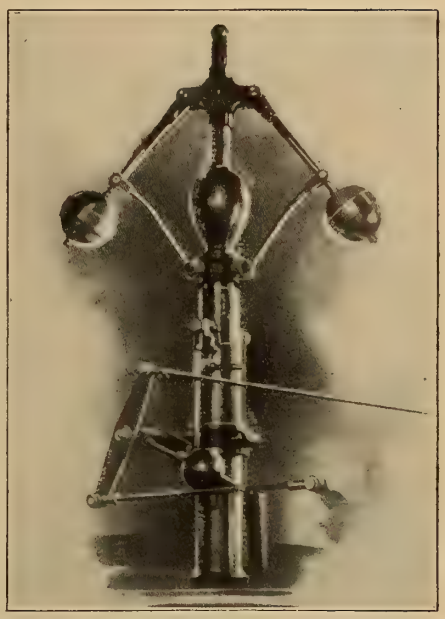
gines running, would not be great. The throttling governor, however, is not in general an economical means of speed control, nor has it the possibilities of close regulation that belong to other types. Its use at present is confined to engines where economy is of small importance and simplicity is desirable; or as a safety governor in connection with other means of control, as with some large Corliss engines, coming into use only in case the regular governor fails to properly adjust the cut-off; and finally in connection with engines where speed must be varied throughout wide limits, as the speed of a shaft governor cannot be changed to any great extent while the engine is running whereas the fly-ball governor may be varied in revolution speed by any suitable mechanical means, or its control of the throttle valve can be affected by similar means of varying the load on the governor itself.

The Corliss engine, of the types showing good economy, is probably the most widely used of all. In this engine, the governor has only to set in position the cams which release the



THE SWEET GOVERNOR AS ORIGINALLY APPLIED TO THE STRAIGHT LINE ENGINE. WEIGHT BALANCED BY ECCENTRIC

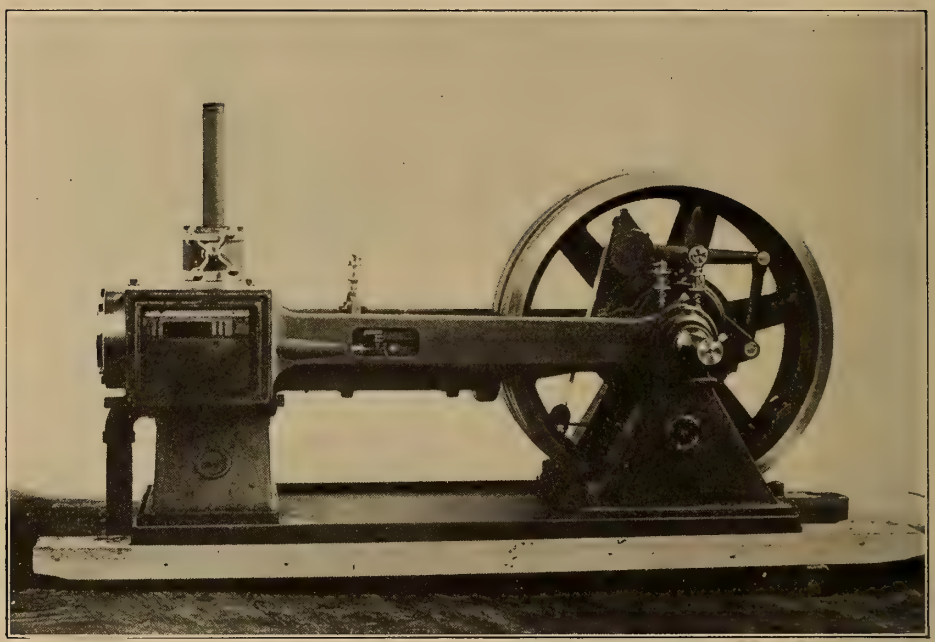
valves at the proper moment, an operation requiring very little force and easily performed by a suitable fly-ball governor, particularly one of the Porter type, where a central weight is used to hold down the balls and allow the governor to run at a high rate of speed. The fly-ball governor cannot be said to be in wide use in connection with other forms of variable cut-off. It has the disadvantage of not being isochronous, necessarily running at a higher speed when the balls are in the highest position, and if the range in speed is minimized a hunting governor is produced. With Corliss engines, dash-pots are regularly provided to control the governors, and at best sudden changes in load cannot be as well taken care of as with high-speed engines with shaft governors. At the same time, large engines are not subject to changes in load as great proportionately as in case of engines of moderate size used in connection with elevators or power service, where one-third or one-half the total load or more may be instantaneously thrown off or on.



USUAL FORM OF CORLISS GOVERNOR

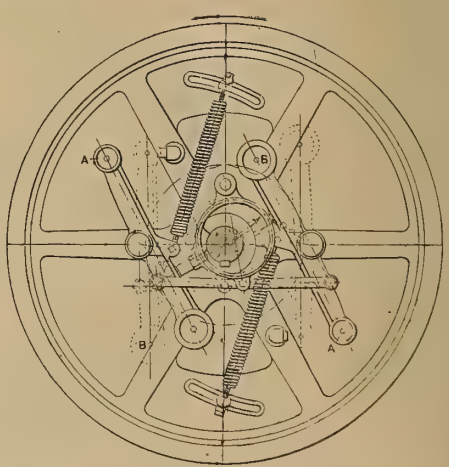
The shaft governor of the centrifugal type has been much improved since its first conception. Whether made with two weights of symmetrical form, or with a single weight balanced against gravity by the eccentric or some other part, as in the governor of Professor Sweet and some later designs, this governor is not subject to disturbance even at slow speeds by the effect of gravity, as in whatever position it may stand, it has no tendency to change the position of its parts. This form has gradually

RITES GOVERNOR AS MADE BY WATERTOWN ENGINE CO. WATERTOWN, N. Y

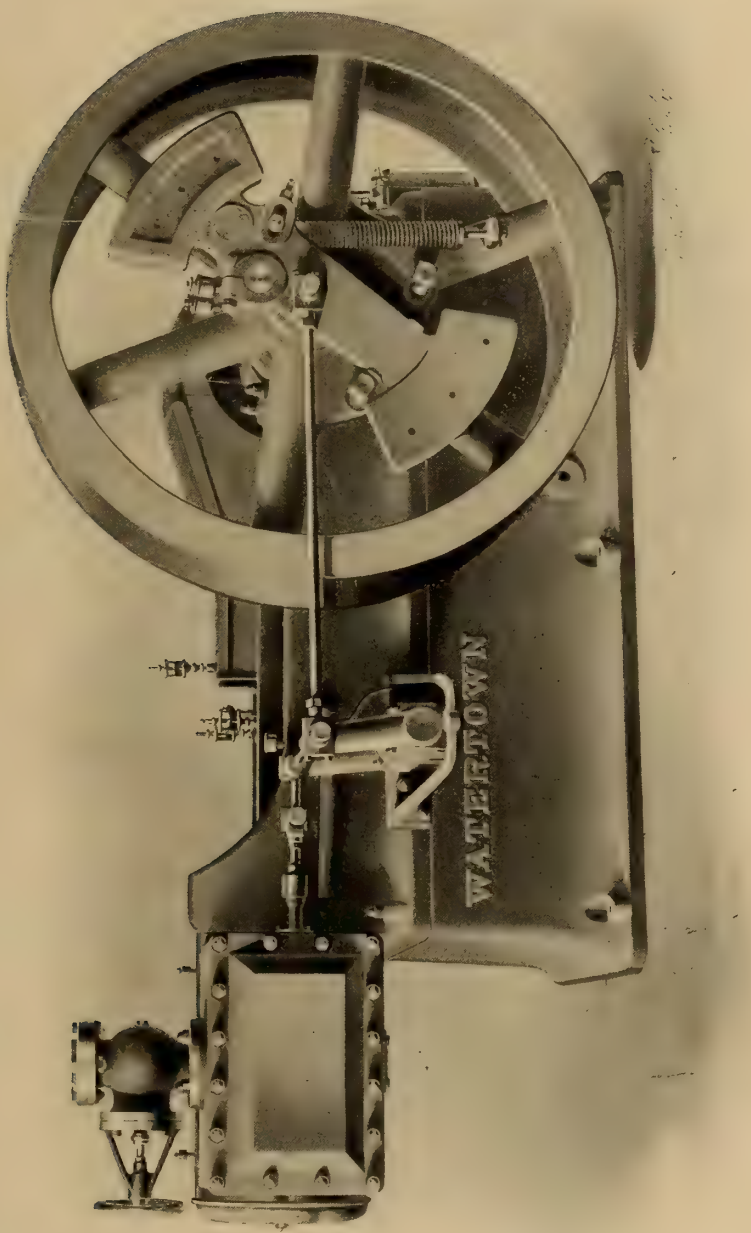


STRAIGHT-LINE ENGINE, SHOWING PRESENT ARRANGEMENT OF GOVERNOR. THE PRESSURE-PLATE IS CUT AWAY TO SHOW THE VALVE. STRAIGHT-LINE ENGINE CO., SYRACUSE, N. Y.

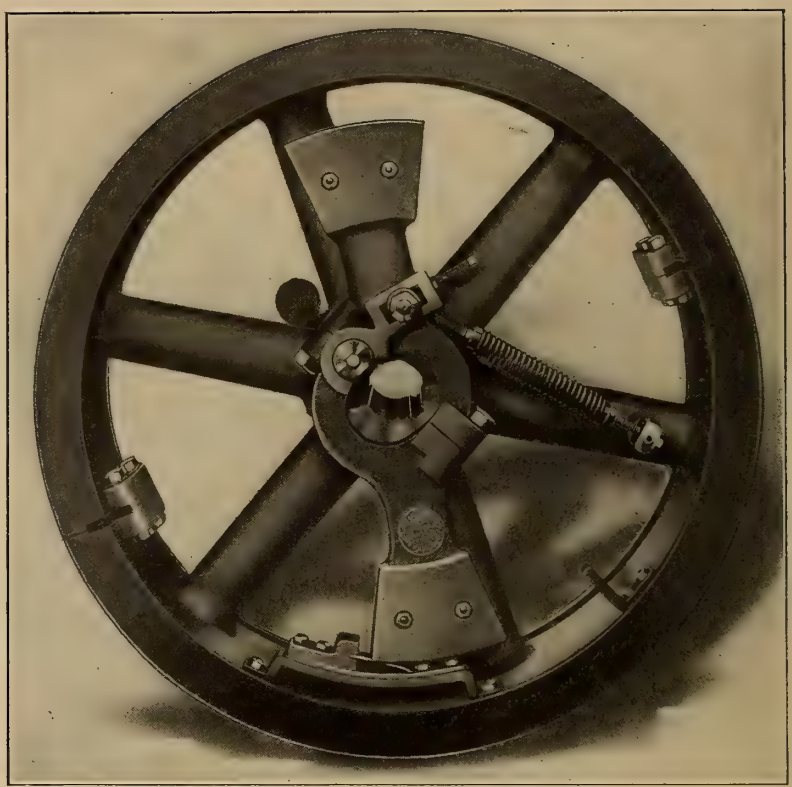
become the recognized type used in connection with what may be called moderate-speed engines with sliding valves, of which very many are in use in heavy power service. It cannot be made isochronous without producing hunting and racing under changes of load, but since it happens that in most severe power service where changes of load are extreme, great accuracy of speed is not required, as for instance in street railway service, the drop in speed from no load to full load is not objectionable. The eccentric may be hung in almost any desired way, which permits the designer to give his steam valve a constant lead, provided the load cannot be reduced so as to allow the engine to run away on the steam admitted through the lead opening alone; or by swinging the eccentric in an arc he may devise a valve motion which will cut off the steam absolutely from the cylinder when load is off, will afford an increasing lead as the cut-off is increased and will have a maximum constant lead from the usual running cut-off to the extreme limit. This refinement becomes more desirable with large engines, and the centrifugal shaft governor, while now practically out of use in connection with high-speed engines of small and moderate sizes, seems to be well adapted to large work.



DOUBLE INERTIA GOVERNOR. HARRISBURG FOUNDRY AND MACHINE CO., HARRISBURG, PA.

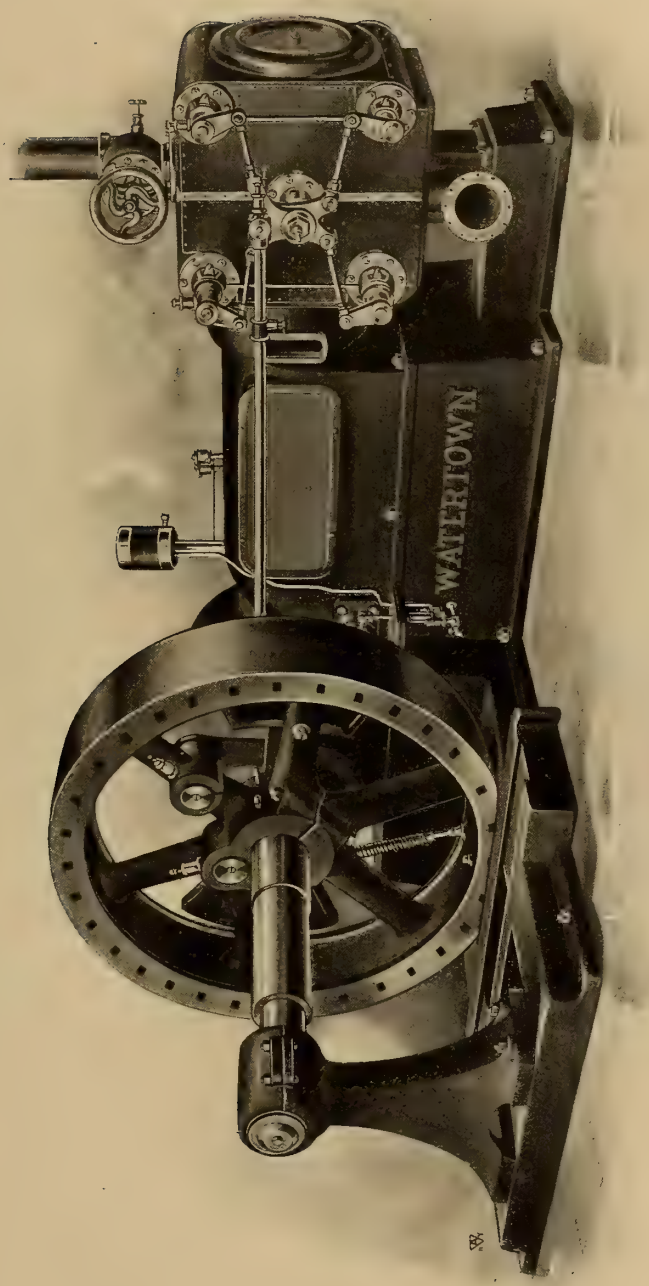


SINGLE-VALVE AUTOMATIC ENGINE SHOWING ARRANGEMENT OF RITES INERTIA GOVERNOR IN FLY WHEEL. WATERTOWN ENGINE CO., WATERTOWN



RITES INERTIA GOVERNOR AS MADE BY RUSSELL & CO., MASSILLON, OHIO

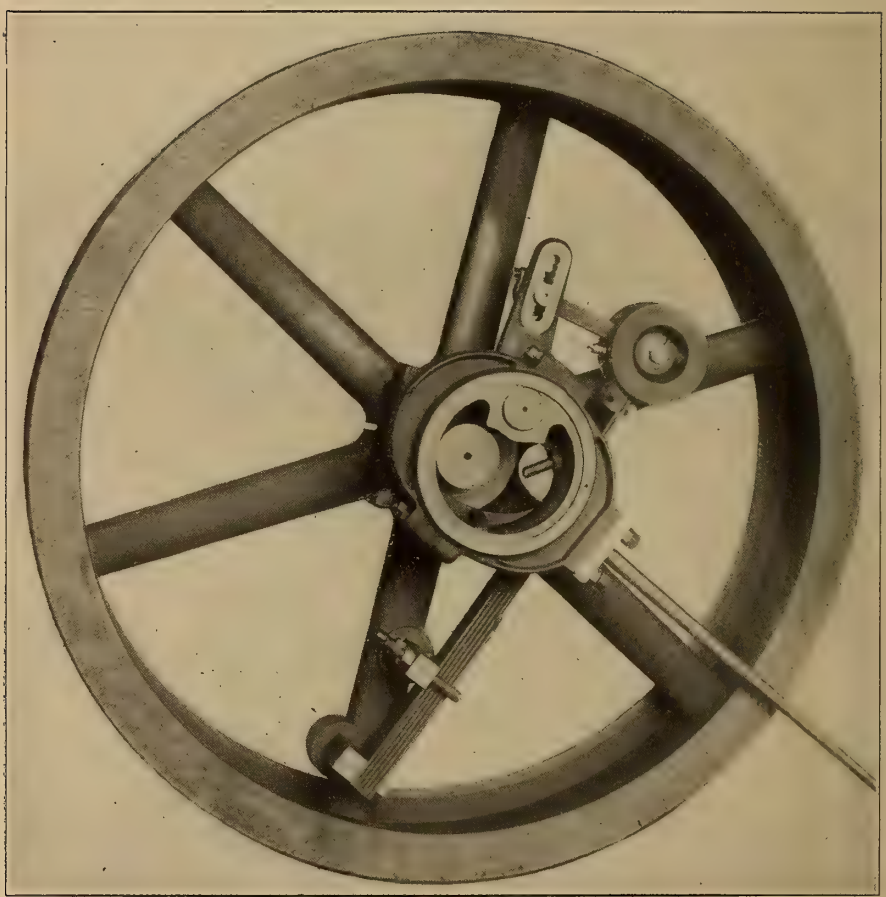
The Rites governor, with its extreme quickness, has practically monopolized the high-speed engine field. In office buildings and hotels in all our cities high-speed engines may be found furnishing current for elevators and maintaining voltage so closely that no variation in lights can be perceived, even when two-thirds or three-fourths of the entire load is cut off within a single second. No other form of shaft governor can be adjusted to give anything like this degree of accuracy. The simplicity of the governor is a most desirable feature, it having but one moving part and one wearing surface. The rules of design developed by Mr. Rites are simple, but are plainly the outgrowth of many years' study and experience with practical results. The limits of the Rites governor are two: lack of balance against gravity, and a necessarily increasing steam lead. It is evident that during half of the revolution of the engine the weight arm tends to fall forward, and during the other half of the revolution tends to fall backward, so that a constant fluctuation is taking place. This is not noticeable at 300 revolutions per minute, but becomes evident at or near 200 revolutions by the tendency of the governor to bump on the stops when shutting down the engine, and by an effect on the steam distribution such that a valve taking steam on the outside edges and driven direct by the governor ceases to cut off shorter on the out-stroke and longer on the in-stroke of the piston than would otherwise be the case, a desirable improvement on the usual unequal cut-off. The movement is plainly shown if the governor is used at slow speed with a valve taking



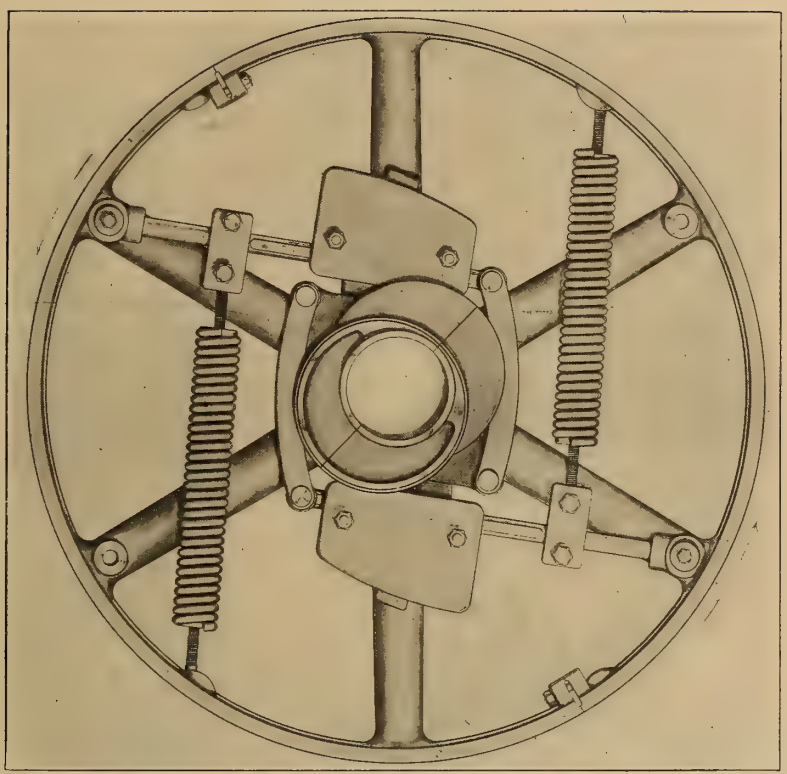
MODERATE-SPEED ENGINE FOR 250-KW. GENERATOR. WATERTOWN-RITES CONSTANT-LEAD GOVERNOR. WATERTOWN ENGINE CO WATERTOWN, N. Y.

steam on the inside edges, as the inequality of cut-off is then made greater instead of less. With revolution speeds below 200, it becomes necessary to provide some form of check to hold the governor arm in position. This may be a simple brake or drag, opposing its friction to the movement of the arm under slight changes in the forces, or a dash-pot performing the same office, but with the difference that the drag operates independent of the speed of motion, while the dash-pot resists more strongly as the motion increases in speed. For example, a street railway engine with plain Rites' governor controlled by a dash-pot might be too sluggish in changes of load, due to the resistance of the dash-pot to the necessary sudden movement of the governor arm; while a drag on the same engine might be perfectly satisfactory.

The other limit of the governor is due to its simplicity, there being but one point at which the eccentric pin center can be placed, and the path of this pin being necessarily curved, the lead cannot be constant. It is found in practice that in order to get satisfactory steam opening at the usual running position of one-fourth cut-off, the governor pivot must be set considerably ahead of the crank center, with the result of excessive leads at late cut-offs, causing the engine to pound heavily on centers when overloaded.



THE ROBB-ARMSTRONG-SWEET SHAFT GOVERNOR, WITH SINGLE WEIGHT BALANCED BY ECCENTRIC



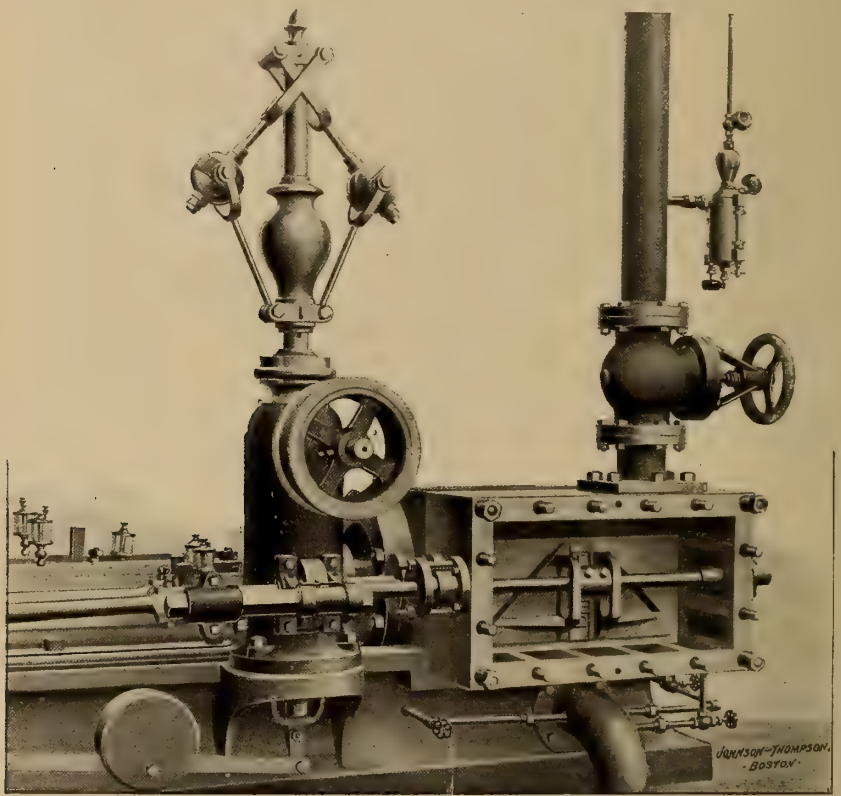
SHAFT GOVERNOR FOR SEMI-CORLISS TYPE ENGINE. RUSSELL & CO., MASSILLON, OHIO

Mr. Rites has recently brought out a form of balanced governor in which the eccentric operating the steam valve is pivoted at a proper point, and a governor arm of his usual form is attached by a link to the former in such a way that the weight of eccentric and strap tends to counterbalance the weight of the governor arm. The result is a balanced governor which has no tendency to change its position during the revolution of the engine. Such a governor can be run at a much higher speed than the Rites governor of usual form; and the eccentric may be so pivoted as to give a constant lead throughout the principal range of cut-off. With a governor of this type, moderate speed engines are constructed with the excellence of steam distribution afforded by the centrifugal shaft governor, and with the extreme quickness of speed control obtained from the well-known Rites governor. The latest tendency is toward heavy, short-stroke engines operating at speeds between 125 and 200 revolutions per minute, therefore adapted for direct connection to generators of moderate size and cost, and provided with Corliss valves driven by a non-releasing valve-gear. The results obtained from these engines, both in steam economy and speed regulation, are in advance of anything previously realized.

There remains only the difficulty of varying speed in automatic cut-off engines with shaft governors, and this problem is not likely to be soon solved. In the nature of the case, the shaft governor must be designed so that its spring will balance the centrifugal force as nearly as required, and this precludes the possibility of any great change of speed without a correspond-

ing change in the stiffness of the spring. With alternating-current generators, it is necessary to bring the speed of two engines into exact accordance in order to put the two generators into the same circuit. The necessary speed variation required is small, and within the possibilities of builders of high-grade slow-speed engines have adopted inertia governors of the Rites type for the operation of Corliss release gear, thus obtaining the extreme quickness of these forms of governors in connection with the slow-speed Corliss engine.

The regulation obtained by the in-



FLY-BALL GOVERNOR ACTUATING A RIDING CUT-OFF VALVE. WATERTOWN ENGINE CO., WATERTOWN, N. Y.

the shaft governor. The present method is to place a small electric motor in the governor case, arranged with proper gearing so that by the operation of push buttons or small switches the spring may be screwed up or unscrewed. The attendant has only to stand at the switchboard, watch the instruments connected with the generator which is about to be put in service, and manipulate the engine switches to vary the speed as required.

It is interesting to note that several

ertia types of governor is fully equal to the most urgent demands upon it to-day. The combination of large motors with lights in a single circuit would have been out of the question with fly-ball governors, no matter how well adjusted. Further improvement will probably be along the lines of the balanced governors of Rites' inertia type, since this form alone affords steam distribution with a constant lead and accurate balancing against gravity as well as a perfect running balance.

HIGHER COSTINGS

THE SUBSTITUTION OF PRECISION FOR UNCERTAINTY IN THE DISTRIBUTION OF SHOP EXPENSE

By Arthur Winder

IT is a bold thing to assert that systems of costings at present in general use are unsound in principle. But it is none the less true that most systems are founded on a principle that the "dead" or "establishment" charges should be debited to costings as a surcharge proportionate to the amount paid in wages. That principle is a failure, and such systems fail because the productive wages are not the true basis on which to make the debit for establishment charges. Among other things these systems:—

(a.) Ignore in a great measure the *time* taken on jobs. Establishment charges, comprising rent, rates, taxes, depreciation, insurance, interest, etc., amount to "so much" per annum or per hour. They are not "so much" per cent. on the amount expended in productive wages. The former are practically fixed, the latter may fluctuate considerably, and the ratio of one to the other is seldom the same for two consecutive days.

There is no real connection between wages and establishment charges. If only one rate per hour were paid in wages, and if a certain amount of work were always done for a given expenditure in wages, there would be some connection between them. These conditions do not prevail, however, and it is idle to discuss this point further. But there is a definite connection between *time* and establishment charges, and establishment oncost should therefore be based on the time spent on jobs.

(b.) The usual methods ignore the *space* occupied by jobs. Establishment charges are "so much" per annum for a certain space or floor area which can be occupied for the purposes of the business. The expenses divided by the number of square yards and by the number of hours actually worked per annum reduces the annual cost for the whole to a price per hour for each yard. And every square yard of floor does truly cost "so much" per hour, whether fully occupied with work or not, and quite irrespective of the amount of wage or bonus earned or not earned by the worker. It becomes apparent, therefore, that oncost should bear some definite relation to the *space,* as well as the time occupied on jobs. Under present conditions, any departure from normal conditions in a shop quite unhinges the costs, because every variation in the wage bill alters the ratio of wages to establishment charges.

(c.) The usual systems do not present true costs. For reasons outlined in a and b the costs themselves are unreliable for the services of the sales department equally with the management, but besides this, the systems referred to tend to hide the minor losses by the gross profit, or vice versa. Costings should show at sight what profits *and* losses have been made and by what department; it should not be necessary to multiply the work of the cost department by the preparation of a number of separate accounts in order to reveal the workings of each department individually.

Costings may be simple or they may be elaborate, but so long as it is

necessary to make "mental notes" of the accidental circumstances which affected each individual costing, so long will it be impossible to claim that the last word has been said on the subject. And unfortunately, the question has only too frequently been asked "why is it that this costing is so different from 'such a one' ?" The reason should appear on the face for purposes of comparison and estimating.

COSTINGS SHOULD BE HELPFUL

(a.) In checking at sight the relative efficiency of the departments at different periods and in allocating the responsibility for variations in the cost of repetition goods.

(b.) In forming a basis for use in the compilation of estimates.

(c.) In the formation of periodical profit and loss accounts. There are two systems widely used for arriving at some or all of these results. One is to debit costings with materials and wages and with a surcharge intended to cover the proportion of the establishment expenses which should be borne by each article produced. This surcharge is made at a fixed rate per cent. on the wage cost. The rate per cent. to be charged is revised year by year in the light of the annual audited accounts. The other system is similar in every respect, with the exception that the rate per cent. is found every month before any of that month's costings are debited with establishment oncost. In the case of the latter, the profit made during each month is found by ascertaining the sum of the balances on the completed costings. Both these systems are varied to the extent of adding the oncost under two or more heads, such as shop oncost and office oncost, or as machine rent, fitting oncost and office oncost.

Perhaps the last mentioned variation most nearly fulfils the three principal requirements of costings, but not one of them fulfils all. They almost entirely fail with regard to the first, and are not really so reliable as they ought to be for the second (because of the periodical alteration on the oncost percentage). They all can be made to fulfil the third object to the extent of enabling the profit to be ascertained in bulk, but they cannot be made to show the profits, losses and net results, and it should be borne in mind that it is possible for a business to be showing a profit while grave and costly mistakes are being made.

Further, it is most important that issues should not be confused. Not a few contend that the whole expenses of a shop should be debited to costings irrespective of the volume of work going through. This is undoubtedly a mistake, as the cost of an article is quite independent of expenses and not incurred on it, and to debit to fifty articles the whole expense of a shop capable of producing double that number is to defeat one's objects in the preparation of costings. We can best bring this point home by citing the following instance: We sent out 10 machines to be built on commission. We had had 10 built previously by the same firm and expected the price to be the same as before, but they wanted to raise the price. In discussing the matter, we learned that when they were building the first batch they were running short time and their expenses had been much heavier, causing a loss. Of course, we objected, and on the following grounds, namely, that if they had not been unusually short of work their expenses would not have been heavier, that the building of our machines had not increased their expenses, and that if they had not had our machines to build their expenses would have been still heavier, and "who would have debited with them then?" They had held the mistaken idea that the work done in any period is guilty of all the expenses incurred during that time. When shortness of work "causes expenses to go up," it is surely simpler and more sensible to show the loss in £. s. d. and to know whether it has

been made an excuse for slipshod work or costly mistakes, rather than to confuse the costings and annihilate one's labours.

It will be well to set out in detail the principal things which influence costings, and see how the three objects already mentioned can best be fulfilled. These are:—

1. Materials
2. Wages
3. Special tools and patterns
4. Expenses of machining

} Showing separately the losses due to wasted material or labor and the why and wherefore of the waste.

5. Floor area and time occupied in bench work and erection.
6. Sundry fixed expenses, or administration account.
7. Sundry fluctuating expenses.

To deal adequately with the first three items is mainly a matter of keeping of records. Many efficient methods of doing this have been made public during the past few years, and as it is the author's object to explain the root principles of cost accounts so that every competent cost keeper may be enabled to formulate a system suited to his firm's needs, it is not necessary to go particularly into this part of the subject now.

The fourth item, expenses of machining, is no doubt best dealt with on the basis of a charge for "machine rent." The machine rent is arrived at as follows: the cost of the machine department in rent, rates, taxes, interest on capital, and obsolesence* of plant, is found and divided by the number of square yards of floor. The resulting figure is the cost per yard per annum. Then against each productive machine (tool grinders, cranes, etc., the use of which is not charged directly against costings are not "productive machines" for the purposes of this article) is allocated the number of yards necessary for its accommodation and proper working. The cost per yard multiplied by the number of yards gives the annual floor cost of the machine, and division by the number of working hours yields the rent per hour of the machine when standing. Add to this the cost of power, lighting, heating, repairs, a share of the unproductive wages of the department, and deterioration* and the cost of the machine when running is revealed. The difference between these two rates is the cost of running overtime.

The floor space not occupied by productive machines and the charges for deterioration* and maintenance of unproductive machines becomes a charge against item 6 (sundry fixed expenses).

Those who do not wish to face the clerical work involved in debiting costings with "machine rent" could advantageously work out percentage rates on the lines indicated at the foot of "The Statement."

Item 5. Floor area and time occupied in fitting and erecting. From what was said at the opening of this article (see a and b, page 517) it will have become apparent that the only satisfactory way of dealing with oncost for fitting and erecting is to charge rent on similar lines to the charge for the machine rent. The following case which came under my personal notice will forcibly demonstrate this point. A new manager in a fitting shop succeeded in two or three months in increasing the output of the shop. But unfortunately, when the costings came to be completed it was found that the wage cost had been slightly increased. The old method of costing was in use and the unfortunate increase in the wage cost seemed doubly bad when 100 per cent. had been added for oncost. When it came to be realized, however, that against an increased wage cost of £40 was to be set an increased earning of £380 (that is, an increased debit for oncost) all doubts as to the economy of the new management vanished. If instead of debiting the costings with 100 per cent. on wages a charge had been made for floor rent, no doubt the very first costing would have revealed the important improvement effected by the new manager. As a matter of fact, the 10

* Irrespective of the number of hours per annum a machine may work, it is liable to become obsolete. This factor forms part of the recognized term "depreciation." The other factor, deterioration, is somewhat dependent on the length of time run. As obsolesence is a fixed liability, and deterioration is not, they are best dealt with separately. See The Statement *post*.

machines built, which at the first appeared to have cost £8 more each (£4 wage and £4 oncost), actually cost £4 more in wage and £38 *less* in oncost.

There is another and most important bearing to this matter. Discussion arose in a certain office on the advisability of accepting an order for some small machines. The price offered would leave a reduced margin of only 2½ per cent. profit. The fortunate arrival of an order for a large machine which it was expected would leave a profit of about 10 per cent. provided the cost accountant with an excellent argument in favour of the acceptance of the first order. He showed that three of the smaller machines could conveniently be built on the space occupied by one large machine and that two sets of three could be erected in the time required to erect the large one. Consequently, six small ones would cost no more in establishment charges than the large machine. The following was the account he presented:—

	Total of Six Small Machines.	One Large Machine.
	£	£
Net selling price	960	610
Debited for on cost at 100 per cent.	150	90
Profited on sale 2½ per cent., 10 per cent., respectively	24	61

Assuming, therefore, that the £90 debited to the large machine was sufficient to liquidate the establishment expenses, the six smaller machines were overdebited to the extent of £60, or, in other words, they, were earning £60 more towards the establishment account than the larger machine was earning. This £60 profit on the establishment account, added to the £24 selling profit, showed a total profit on the smaller machines of £84 as against the £61 made on the large machine. He suggested also, that although £84 on the smaller machines would not be equal to 10 per cent. on the turnover, it would still be better than the £61 (or 10 per cent.) on the larger one. By way of clinching his argument, the accountant remarked that there was vacant space sufficient for the erecting of the small machines, and that if it were not utilized there would be a loss on the establishment account, because the oncost percentage on the reduced wage bill, due to the shop not being fully occupied with work, would not be sufficient to meet the expenses. That order was taken.

The last argument of the cost accountant touches a difficulty affecting more or less every workshop. That difficulty is "how to ascertain the loss due to shortage of work." That such losses should be shown clearly and in £. s. d. there is no doubt, but the percentage method of adding oncost offers no opportunity of keeping account of that and similar losses as part of the day's work. If one were prepared to go to the expense and trouble, such losses could possibly be ascertained on the old system, but such trouble and expense is not undertaken by any who did not thoroughly realize the subtle acting and reacting upon one another of selling price, oncost, and profit.

By way of making our argument clearer, let us take an imaginary case of three years' trading (the argument will equally suit the case of those who vary their charge every month for establishment oncost, if the word month be substituted for year). The first year, then, we built 100 machines at a cost in wages of £10,000 and in establishment expenses of £10,000 (including unproductive wages). In other words, the ratio of establishment expenses to productive wages was as 1:1, or 100 per cent. The next year our production fell off and only 50 machines were completed at a wage cost of £5,000. We were not able to cut down the establishment expenses proportionately, but with the reductions in cost of power, lighting, heating, bank charges, maintenance of machines and tools, unproductive wages, etc., the establishment account came down to £7,000. At the end of the year, when the accounts have been completed, it ap-

pears that instead of debiting costings with 100 per cent. on productive, we ought to have debited them with 140 per cent. Under the circumstances, we are in the habit of saying "the machines have cost us more than we expected," but surely it cannot be contended seriously that the machines built actually cost more because part of the floor was not fully occupied with work. It was the vacant space—i. e., bad trade—which was so costly, and if we had been made aware month by month of the real state of affairs, that is, that at least £25 a month was being lost because of the shortness of orders, then our negotiations with prospective customers might have been very beneficially effected. We should have realized most forcibly that to sacrifice part of our selling profit with a view to increasing production would be profitable business. Looking for ways and means of improving trade and methods, we find that the first year, which was a year of normal output, our establishment expense was equivalent to £100 per machine, that the shop accommodated 10 machines at a time and that they took 30 days to build. This establishment expense of £100 per machine was therefore equal to a cost of £3 6s. 8d. per day per machine. Our selling profit in that year was equal to 10 per cent., and we decide to sacrifice some of this, if necessary, to secure more business, and we also arranged to debit costings for establishment oncost at £3 6s. 8d. per day for the time the machines are on the floor, on the assumption that in the third year they should not cost any more than they did in the first year. Now let us assume that we secure more business, 50 per cent. more than in the first year. To cope with it, it becomes necessary to work overtime. This entails additional wage cost on account of paying time and a quarter or time and a half for overtime work. We cannot well afford this increased expenditure, but on going further into the matter we find that it will not be necessary to reckon the establishment oncost at the same rate for overtime work as for day work, owing to the fact that rent, rates and certain other expenses do not vary according to the length of time worked. Then again, although we cannot increase the number of men engaged on each machine under normal conditions without some sacrifice, for there is a limit to the number who can be economically employed on any job, yet within limits this is better than paying time and a half for long overtime work. Calculations are made and the happy mean found, more men being engaged on the machine and some overtime run. The net result is that the wage cost is sent up £10 per machine and considerable time saved in the building; £23 6s. 8d. being saved on the establishment account in consequence. The difference of £13 6s. 8d. is a little addition to the profit which will be some compensation for any little selling profits which may have been sacrificed and some consolation for the worries and risks which ever attend overtime work. The following figures present the case concisely:—

Cost per machine, first year:		
Wage cost		£100
Establishment cost, 30 days at £3–6–8 per day		100
		£200
Cost per machine, third year:		
Wage cost		£110
Establishment cost, 20 days at £3–6–8	£66–13–4	
Overtime equal to 4 days duration at ⅓ of day rate	10– 0–0	
		76–13–4
		£186–13–4

The £13 6s. 8d. saved in establishment cost on each machine is equivalent to £2,000 on the 150 machines built. It should be borne in mind, of course, that, had the costings been conducted in the ordinary way, the increased wage cost of £10 per machine would have been swollen by the addition of £10 (100 per cent.) establishment oncost, the net result being that, on paper, they had cost £20 more than those built in the first year. As a matter of fact, the paper costs would have been wrong to the extent of £33 6s. 8d., because

the third-year machines actually cost £13 6s. 8d. less than those made in the first year, not £20 more. We need not stay to speculate whether this error would have so influenced the sales department as to lead to a raising of prices and a consequent shutting out of orders.

The above example is intended to demonstrate that a rent method is a sounder means of debiting costings with establishment than is a percentage method, but it is not put forward as a complete solution of the problem. There are many factors which affect the amount of the surcharge for oncost which are not generally taken into account in any definite way. For instance, unoccupied space in a machine shop is an establishment expense that cannot fairly be charged up to the works manager's account. On the other hand, there is not the slightest reason why he should be given credit for effecting a reduction in costs if such reduction is due rather to the installation of additional or improved plant than to increased efficiency. Extensions and additions generally involve decreases in the percentage of costs of administration. A little reflection will show, however, that the old works and plant do not necessarily cost either more or less per annum. Alterations in the equipment, in office expenses, and so forth, affect the administrative costs, but the expenses truly appertaining to the existing productive departments (the machine rents and floor costs) cannot, if the accounts are properly conducted, be affected by any variation of trade which may be introduced in their vicinity. It is consequently necessary, in order to secure some measure of precision and to allocate responsibility, that a separate surcharge be made to cover those expenses which do not vary with the turnover and which are not directly responsible for fluctuations in the cost of production. This brings us to:

Item 6. Sundry fixed expenses, or administration account. This is made up of losses on unoccupied space inside or outside the shops, fixed office expenses, advertisements, insurance, as much power, light, heat, repairs and labouring wage as would be necessary to keep the buildings and plant in order if standing, travelling, patents, and stores expenses. Being independent of the volume of business done, these expenses are best debited to costings pro rata to the debits for machine rent and bench and erecting oncost. "Bad trade" account can then be debited for losses on administration account in accordance with the ascertained losses in the productive departments*. The total loss due to shortage of work is thus automatically taken account of, records of cost are kept on a common basis, responsibility for bad results can be brought home to the parties concerned, and the selling department is not confused and misled by costs which contain an unknown leaven of inflation. It may very reasonably be asked if it is advisable or necessary to go to the trouble of separating the shop expenses from the rest of the fixed charges. The work involved is not nearly so great as it appears on paper and requires to be done only once and supervised year by year in the light of the annual accounts. Many firms find the ordinary costings quite inadequate for the purposes of the management, and have various additional statistics extracted to aid them in their constant struggle to secure and maintain efficiency. It would consequently appear to be necessary so to reconstruct our costing systems that necessary information is collected automatically as part of every day's work, one comprehensive system carried through with a minimum of clerical effort and liability to err. To do this it is necessary to separate shop and administration expenses. The primary advantages offered by

* Losses due to bad trade only are debited to bad trade account. Losses due to faults of foremen, order clerks, draughtsmen, etc., are debited to a waster account, to which are also transferred the wastages referred to in items 1, 2 and 3, page 519. The losses caused by each department are shown clearly in the monthly trading account, and scrutinized.

such treatment of the accounts are:—

a. That an alteration in the equipment does not alter the prices already calculated for the shop oncosts.

b. That a rise or fall in the rates of wages, the employment of better or worse workmen, a variation in the ratio of men to boys, or an increased wage bill by reason of bonus or overtime payments, do not become magnified by the addition of "so much" per cent. for oncost.

c. That the efficiency of the shops and other departments can be gauged without extraction of additional information, because the work of the shops is not affected by or lost to view in the economies or extravagancies of other departments.

d. That costings completed after any alterations in the equipment or in the administrative arrangements have been made are on "all fours" with those previously completed, and can consequently be compared without the necessity of "making mental notes."

The installation of additional plant is dealt with in this way. The rent value of the floor area required by the new equipment is taken out of the administration account and its machine rent calculated as stated on page 519. Future costings will, of course, be debited with a slightly less rate of oncost on administration account.

Item 7. Sundry fluctuating expenses, requires but little explanation. As the name implies, it is made up of those expenses whose magnitude depends on the volume of business transacted. Whatever the proportions of material, labour and oncost of which a costing is composed may be, certain expenses bear a definite relation to the whole, that is, to the invoice price, not to the wage cost. Such expenses can be properly provided for only by the addition of a percentage to the whole cost of production.

Reference to the Statement will show that under the head of fluctuating expenses we paid out last year £1,260. Our turnover was £75,000, from which have to be deducted discounts, selling commissions and profit,

EXAMPLE OF COSTING.

Description ..... Job. No. 28,107.
..... Account No. 361.
..... Date finished, March 1, 1907.

	Labor.	On Costs.	Material.	Totals.
			200–00–00	200–00–00
Machinery, ordinary time	50–00–00	40–00–00		90–00–00
Machinery, overtime	*5–00–00	3–00–00		8–00–00
Bench work, ordinary time	50–00–00	16–00–00		66–00–00
Bench work, overtime	20–00–00	8–00–00		28–00–00
Erecting, ordinary time	80–00–00	23–00–00		103–00–00
Erecting, overtime	40–00–00	7–00–00		47–00–00
Total ordinary time	180–00–00	79–00–00		
Total overtime	65–00–00	18–00–00	200–00–00	542–00–00
Standing charges 38% on £79		30–00– 5		
Standing charges 24% on £18		4– 6– 6		34– 6–11
	245–00–00	131– 6–11	200–00–00	576– 6–11
Fluctuating charges 2% on		11–10– 7		11–10– 7
	245–00–00	142–17– 6	200–00–00	587–17– 6
Add 1/9 to leave 10% profit				65– 6– 5
Add 1/19 to allow 5% sales commission				34– 7– 7
Add 1/19 to allow 5% discount				36– 3– 9
				723–15– 3
Particulars of amounts transferred out:				
To drawing office waster account	2–00–00	8–00–00	1–00–00	11–00–00
To stores waster account			1–00–00	1–00–00

Remarks:—
Casting No. 431A broken in handling. Erection delayed 16 hours. Cause, defective casting. Fault, defective part passed as correct by draughtsman.
Comparison with previous costing:—
Material, higher; advance in MS bar. Labor, higher; increased average rate of pay. On costs, 1 lower; standing charges 2% less, better workmanship both machining and erecting, bench work same as last. Overtime, as last.

THE STATEMENT.

Values	£45,000	....	....	....	....	2,250	9,000	33,750	....	
Floor area, square yards	5,600	164	100	240	164	600	1,840	1,992	500	
	Totals.	General Offices.	Drawing Offices.	Stores.	Tools.	Bench.	Erecting.	Machinery.	Standing.	Fluctuating.
Interest on debentures or loans	2,200	....	....	....	....	110	440	1,650	....	....
Obsolescence of plant, etc.	2,000	....	200	....	....	....	....	1,800	....	....
Rent, rates, taxes	1,400	41	25	60	41	150	460	498	125	....
Insurance	400	....	....	....	....	....	....	....	400	....
	6,000	41	225	60	41	260	900	3,948	525	....
Deterioration	1,800	....	....	....	....	80	320	1,400	....	....
Power	800	....	....	....	....	....	100	650	50	....
Wages—unproductive	2,450	490	90	140	340	70	200	570	150	....
Lighting	210	10	10	10	10	30	40	80	20	....
Heating	99	2	1	30	2	8	23	21	12	....
Repairs (material and wage)	1,100	....	....	....	700	50	100	200	50	....
	12,459	543	726	240	1,093	498	1,683	6,869	807	....
Interest (banks)	200	....	....	....	....	....	....	....	....	200
Salaries	1,200	....	....	....	....	....	....	....	1,200	....
Traveling expenses	300	....	....	....	....	....	....	....	300	....
Bank charges	480	....	....	....	....	....	....	....	....	480
Law costs	60	....	....	....	....	....	....	....	....	60
Patent fees	36	....	....	....	....	....	....	....	36	....
Packing and painting	520	....	....	....	....	....	....	....	....	520
	15,255	543	726	240	1,093	498	1,683	6,869	2,343	1,260
	.....					....	....	....	s 41	....
	.....	To Standing Charges.	To Standing Charges.	To Standing Charges.	To Shops.	....	....	....	r 502	....
	.....					....	....	....	s 225	....
	.....					....	....	....	r 501	....
	.....					....	....	....	s 60	....
	.....					....	....	....	r 180	....
	.....	....	....	....	....	s 5	17	19	....	....
	.....	....	....	....	....	r 142	437	473	....	....
Standing	.....	....	....	....	....	265	917	3,967	851	....
Running	.....	....	....	....	....	380	1,220	3,394	3,001	1,260

Price per yard standing	8/10	10/1	A price for each machine. 75% 2% on cost value
Price per yard running	21.6	13/3	38% £63,000 of goods
Price per yard overtime	12/8	13/3	24% sold last year.

Alternative charge, see page 519 for machinery oncost on a normal productive (machinery) wage bill of £4,000:

Per cent. on cost ordinary hours	184%
Per cent. on cost overtime (on ordinary rates of pay)	83%
Debit bad trade account or other responsible account for standing losses on reduced wage bills	100%

the balance of £63,000 representing the cost of the goods sold. Last year then, we required an addition of 2 per cent. to the costings to cover fluctuating expenses, and a similar debit will be required in the new year.

The necessary provision for profit, discounts and selling commissions will be made in the ordinary course—and it is not necessary to consider it here.

THE STATEMENT

It may be advisable to state that the entries at the head of the statement indicate the basis on which some of the expenses have been allocated to the departments. For instance, the first item, interest, has been allocated in proportion to the values, while rent, rates, etc., have been allocated in proportion to the area. The allocation of wages, repairs, etc., is according to previous experience. It is a good thing to prepare a statement on similar lines—it is not a difficult task—and to keep it at hand for constant reference; it will be found most useful.

The author hopes to explain hereafter a simple method of compiling monthly (or other short date) profit and loss accounts.

WILLIAM SYMINGTON AND THE BEGINNINGS OF STEAM NAVIGATION

By Robert Cochrane

In our last issue we described the experiences of Fulton in France, and showed the difficulties against which he had to contend in the development of his ideas in connection with steam navigation.

There seems to be little doubt that the idea of applying the steam engine to the propulsion of boats was in many minds at the beginning of the last century. As a matter of fact, the perfection of the steam engine by Watt and his associates naturally directed the thoughts of men to its wider applications, and the steamboat, as well as the locomotive, was bound to come in the natural course of time, if not through one man's efforts, certainly by those of another.

Symington certainly had altogether correct ideas as to the feasibility of the applicability of steam to navigation, and the success which attended his experiments showed very clearly that he had grasped the essentials of the problem. The times, however, were not quite ripe, and it remained for Fulton, in America, and Bell, on the Clyde, to reap where he had sown.—THE EDITOR.

CHAIR MADE FROM THE WOOD OF THE ORIGINAL STEAMBOAT OF SYMINGTON OF 1789, NOW IN POSSESSION OF ROBERT BARR, ESQ., OF FALKIRK

THE early pioneers of steam navigation, working within narrow limits, scarcely foresaw the gigantic power and importance of their experiments and inventions, which were destined to make our oceans highways of commerce, and intercommunication, never dreamt of in their crude attempts, which at first had but the aim of quickening a few barges in our canals. These canals cradled steam navigation in that the first really successful experiment, one hundred and four years ago last March, took place on the Forth and Clyde Canal near Falkirk; there the *Charlotte Dundas,* built under the superintendence of William Symington, went through her trials successfully, dragging two barges behind her, to the admiration of all who witnessed the feat, and the satisfaction of Lord Dundas, the chief promoter. Circumstances, as we shall see, went against the inventor and the inventions; development was irregular, and broke out again under Fulton in America in 1807, and Henry Bell and his *Comet,* on the Clyde, in 1812, both of whom profited by what they had seen of the *Charlotte Dundas.* If the canal cradled the steamboat, it did the same for the iron vessel. It was Thomas Wilson, a young Scottish boat builder, who, in 1816, constructed an iron boat, the *Vulcan,* at Faskine, Lanarkshire, for passenger service on the Monkland Canal. Wilson was jeered at for thinking that iron could float; but his vessel ran for sixty years, and was the pioneer of our iron and steel merchant marine.

In endeavoring to get a clear view of the beginnings of steam navigation, we are confronted with a great deal of confusion, contradiction, and evident misstatement. In piloting our way through their maze, we will

endeavour to give only established facts. The confusion exists as to the relative amount of credit to be given to Patrick Miller, of Dalswinton, the promoter of the first experiments; to James Taylor, tutor in his family, and to William Symington, the practical engineer. Both Taylor and Symington claimed the invention, and in the strength of Taylor's claim his widow, after his death in 1825, enjoyed a pension of £50 a year. Symington was rewarded with neglect and disappointment, save for the gift of £100 from the Privy purse and another £50. His widow was cared for by Dr. Bowie, a son-in-law, who saw the remains of Symington laid to rest in St. Botolph's, Aldgate, in 1831, in a corner just opposite the end of the Minories.

We believe that a good case can be made out for Symington from his own narrative published at Falkirk in 1829; by the help of a sheaf of his letters from the archives of Mr. Robert Wight, son of his friend and business agent in Edinburgh; by a document submitted to the trustees of the Forth Ferries, and from other independent testimonies. The articles on Miller, Taylor, and Symington in the "Dictionary of National Biography" are slightly contradictory. It is unpardonable that the Christian name of Symington should be given as "Andrew" under the article on Miller. The writer of the biography of Taylor claims that he may have suggested the use of steam to Patrick Miller, of Dalswinton, for his double-hulled vessels, and that he successfully combated the argument which he raised against its use.

Professor T. H. Beare, of the Edinburgh Engineering Chair, puts the matter thus:

"The success of the *Charlotte Dundas* entitles Symington to the credit of devising the first steamboat fitted for practical use. It is possible that Jonathan Hulls constructed a working model before 1737. But if he did, the boat, like that of Patrick Miller, was nothing more than a curiosity, while the *Charlotte Dundas* was constructed on the same principles as the present steamship. In his successful patent of 1801, Symington employed a piston rod, guided by rollers in a straight path, connected by a connecting rod to a crank attached directly to the paddle-wheel shaft, thus devising the system of working the paddle-wheel shaft which has ever since ben in use."

In a memorial presented to trustees of the Fife and Midlothian ferries between Kinghorn and Leith, Symington himself describes what he had done thus, and its importance cannot be exaggerated:

"In place of a cylinder erected in a vertical position, with the piston-rod acting upwards, and the working beam and the other heavy and complicated apparatus of the old steam engine, he placed the cylinder in a diagonal position, making with the horizon an angle of less than 45 degrees, and, by coupling to the end of the piston-rod a crank and arm, reproduced a rotary motion without the intervention of a lever or beam, or the other apparatus connected therewith."

This achievement makes out a very favourable case for William Symington.

Before quoting Symington's own narrative, it may be permitted briefly to review these pioneer experiments in steam navigation which made it possible for Fulton and Bell to develop them in a wider field. Patrick Miller, of Dalswinton, Dumfriesshire, who at one time was a common sailor, was a successful business man in Edinburgh, with a strong bent towards the field of invention, especially in connection with ordnance and shipping. In 1773 his address is given as a "banker" in James Court, and he did become an influential director of the Bank of Scotland, as well as a large shareholder in the Carron Company. In 1785 he purchased the estate of Dalswinton, Dumfriesshire, and was the landlord of Robert Burns, when

in the farm of Ellisland. He gave the poet a present of money when in Edinburgh. Patrick Miller spent much time and money in shipbuilding experiments, his great idea being the construction of ships with two or three hulls, propelled by paddle-wheels placed between the hulls and worked by men from capstans on the deck. In January, 1786, he launched the *Edinburgh* on this plan at Leith, and in the following year another

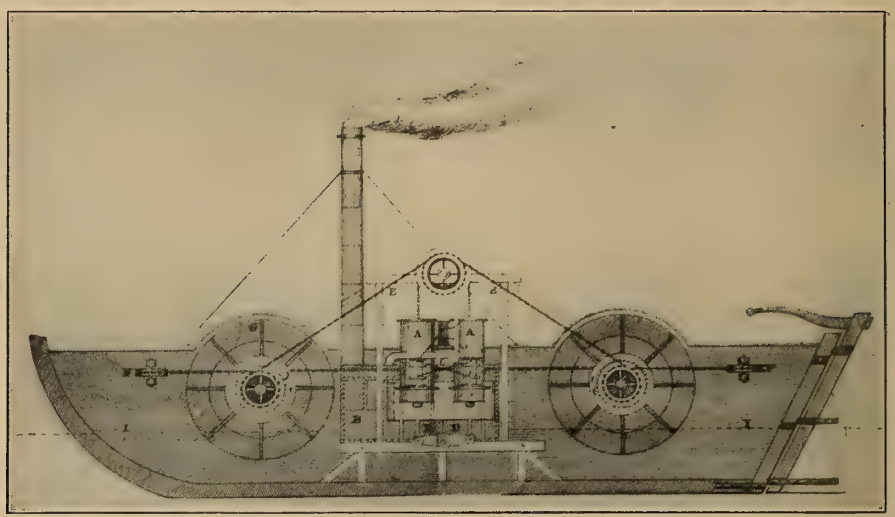
DESIGN FOR STEAMBOAT BY JOHATHAN HULLS; FROM HIS PAMPHLET OF 1737

double vessel, 60 feet long, which had cost him £3,000. It is an interesting point, which probably will never be clearly set at rest, as to who first suggested the use of steam to Miller. In all probability, James Taylor, tutor in his family, who had practical experience of working the "wheels," as the paddles were then called, made the suggestion, and conquered, as we have said, Miller's objections in the matter. Miller, who had seen Symington's model of his road engine, and wrote in 1787: "I have reason to believe that the power of the steam engine may be applied to work the wheels. * * * In the course of this summer I intend to make the experiment, and the result, if favourable, shall be communicated to the public." And so followed the experiment on Dalswinton Loch, on Nov. 14, 1788, with the pleasure boat, fitted with cylinders of 4 inches diameter, made by a brass-founder named Watt, in Edinburgh. James Nasmyth, in his autobiography, says that Robert Burns and Lord Brougham were both present; the presence of Brougham has been disproved, although Burns may have been there. Experiments were made with Miller's pleasure boat fitted with a larger set of engines constructed by the Carron Company, and tried on the Forth and Clyde Canal in December, 1789, when a speed of 7 miles an hour was attained. The clumsiness of the chain and ratchet system, as seen in the illustration, condemned it, however. Here is a letter from Patrick Miller to the Carron Company, on the subject:

Dunfermline, June 6, 1789.

Gentlemen;—The bearer, Mr. William Symington, is employed by me to erect a steam engine for a double vessel, which he proposes to have made at Carron. I have therefore to beg that you will order the engine to be made according to his directions. As it is important that the experiment be made soon, I beg also that you will assist him, by your orders to the proper workmen, in having it done expeditiously. I am ever, with great regard, gentlemen, your most obedient humble servant,

PATRICK MILLER.



THE FIRST STEAMBOAT OF MILLER AND SYMINGTON, TRIED ON THE FORTH AND CLYDE CANAL IN DECEMBER, 1789.

There is no word here of the presence of James Taylor, who claimed that he superintended the construction of both engines. Miller's friend, Robert Cullen, wrote in 1790 to James Watt, expressing dissatisfaction with Symington's engines, on account of the great loss of power by friction, and inquiring if Boulton Watt's engines would suit. The reply does not seem to have been encouraging, and Watt, who had all the jealousy of an inventor, seemed to regard Symington's engines as "an attempt to evade an exclusive privilege." This fact may furnish reason enough why Miller abandoned further experiments after spending about £30,000 on these and other shipbuilding ventures.

We present now a brief summary of the facts in the career of William Symington, as drawn up by himself and printed at Falkirk in 1829, with the view to a Parliamentary investigation of his claims. A copy of this document in the possession of his friend, James Blaikie, of Panmure Foundry, Edinburgh, was reprinted in 1863. He had a conversation with a gentleman who knew Blaikie well; this gentleman was quite clear as to Symington's share in the invention from the facts communicated by Blaikie. The document is now exceedingly scarce, and Professor J. H. Beare, of the Engineering Chair, Edinburgh University, author of the account of Symington in the "Dictionary of National Biography," does not mention it in this bibliography, appended to his article.

"I was born at Leadhills, in the county of Lanark, North Britain, in the year 1764, of not wealthy, but respectable parents. I was intended for, and partly educated with a view to, the church, but my natural turn for mechanical philosophy led me to change my object and to direct my studies to the exercise of the profession of a civil engineer.

"Having commenced this pursuit, I made several improvements in the steam engine, for some of which I procured His Majesty's letters patent, and introduced them, with considerable advantage, into different parts of England and Scotland.

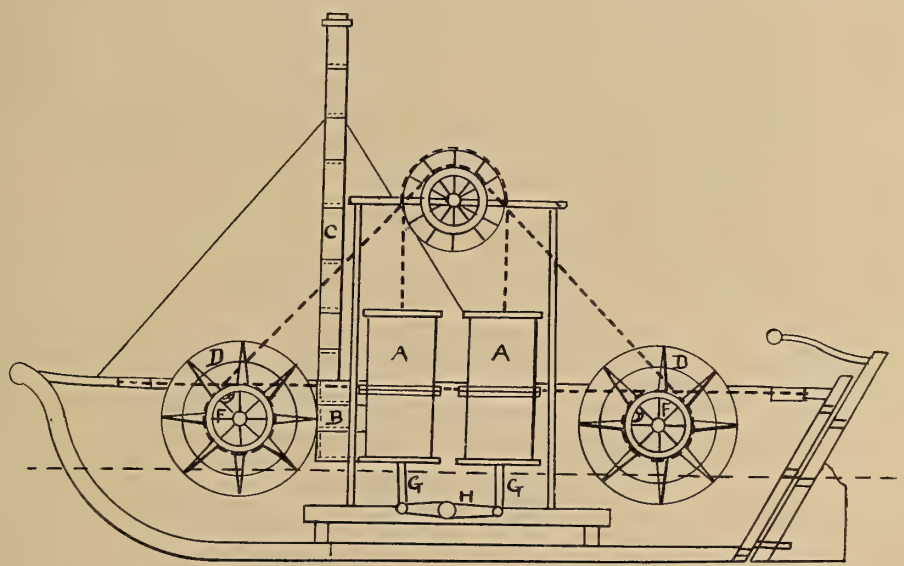
"In July, 1786, I went to Edinburgh, and submitted to the professor of the university, and to other learned and scientific gentlemen, the model of a carriage which I had invented and intended to be moved on public roads by the power of steam. Upon this occasion I met the late Patrick Miller, Esq., of Dalswinton, who had been informed not only of my model of a steam carriage, but

of my previous improvements on the steam engine, by Mr. James Taylor, a school companion of mine, and who was then tutor in Mr. Miller's family. When Mr. Miller called upon me at the house of my much respected friend, the late Gilbert Meason, Esq., he was shown the model of the steam carriage, and Mr. Miller was pleased to say: 'It bids fair to improve greatly the commerce of the country by facilitating the conveyance and reducing the rates of carriage.'

"Mr. Miller also mentioned that he had spent much time making experiments as to the propelling of vessels upon water, by using wheels in place of sails or oars. These wheels he had hitherto put in motion by applying the strength of men to the turning of a handle or winch. He said he had also attempted to work them by the power of horses, but none of these powers had sufficiently answered his purpose.

"I stated without hesitation that I believed a steam engine might be constructed to propel Mr. Miller's boats, by communicating a rotatory motion to the paddles by the alternate action of the ratchet-wheels, in the same manner as proposed in the model of the steam carriage then before him, which would render altogether unnecessary the aid of a fly-wheel to regulate and equalize the effects of the steam engine in turning the revolving oars."

Patrick Miller seemed favourably impressed with the proposal for applying the steam engine to the propelling of boats, and if Symington believed he could accomplish this with safety, Miller promised to make an experiment on a small scale. Symington proceeded to erect the small steam engine for which he had previously taken a patent, having two cylinders of 4 inches diameter, each making an 18-inch stroke. "This engine," he continues, "having been constructed by my direction and under my eye, I caused it to be fitted on board a double-keeled vessel then lying upon a piece of water near the house of Dalswinton, and this being done, an experiment was made in the autumn of the year 1788, in presence of Mr. Miller and various



MILLER AND SYMINGTON'S STEAMBOAT OF 1789

AA, cylinders; *B*, boiler; *C*, funnel; *DD*, paddle wheels; *E*, connecting chain; *FF*, ratchet wheels for communicating motion to paddles; *GG*, lower piston rods; *H*, beam.

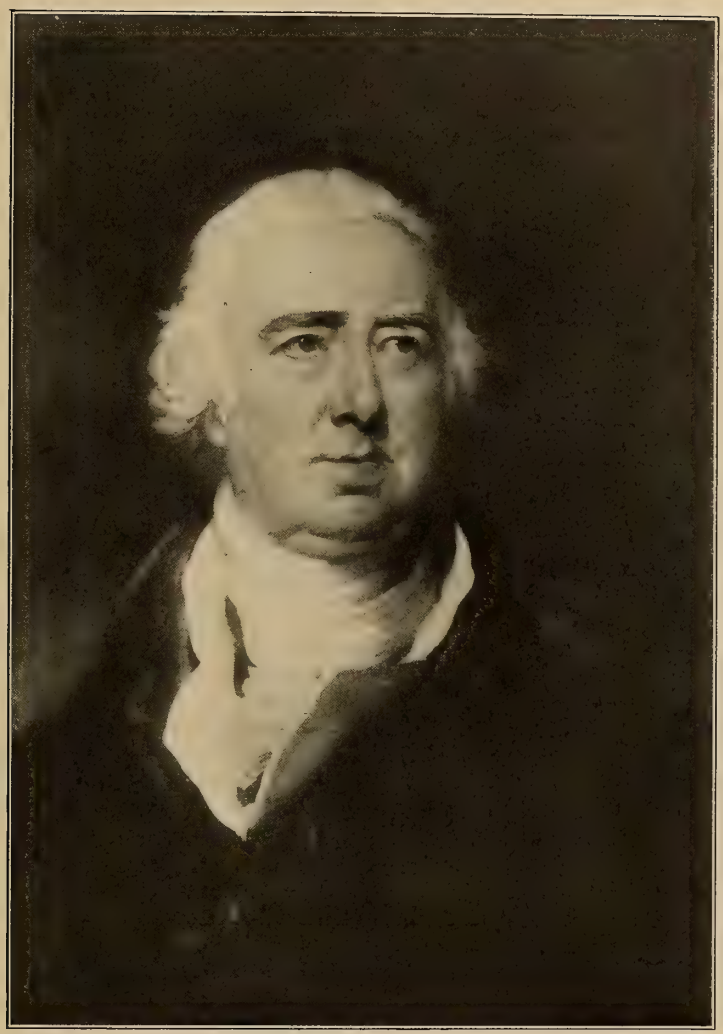
other respectable persons, and the boat was propelled in a manner that gave such satisfaction that it was immediately determined to commence another experiment upon a more extended scale.

"The second experiment was made on the Forth and Clyde Canal. The machinery was executed at Carron Iron Works under my direction, and was erected in a boat belonging to Mr. Miller, which had been previously built and fitted with paddle-wheels for the purpose of making experiments as to the effect of these wheels turned by the labour of men, already described. I fitted into this boat a steam engine with two cylinders, each 18 inches in diameter and making a 3-foot stroke, and in the month of October, 1789, I took on board Mr. Miller, the late John Adam, Blairadam; John Balfour, Pilrig; Ambrose Tibbets, esquires, members of the Carron Company; Mr. James Taylor, my school companion, and David Drysdale, residing at Bankside, near Bainsford, an experienced sailor, to whom I gave the helm, and in the presence of hundreds of spectators who lined the banks of the canal, the boat glided along, propelled at the rate of five miles an hour, and all the parties interested declared themselves satisfied with the success of my performance. I have herewith produced the original drawing, with an account of the expense of the machinery, which, exclusive of the cost of the boat that previously belonged to Mr. Miller, amounted to £363 10s. 10d."

These experiments satisfied Symington of the possibility of driving vessels by steam and paddles, but Miller, at this period "very unaccountably withdrew himself from public business," devoting himself to the development of his estate at Dalswinton. Symington, too, was called away to construct machinery at the Warlockhead Lead Mines; the steamboat experiments were arrested; the boat was dismantled and its machinery laid up in Carron Works. In the summer of 1800, however, Thomas Lord Dundas, of Kerse, a large shareholder in the Forth and Clyde Canal, approached Symington with the result that another series of experiments was begun in January, 1801, and continued until April, 1803, at a cost to that nobleman of about £7,000. Symington continues:

"A steam engine was erected with a cylinder of double power, 22 inches in diameter, and making a 4-foot stroke, and fitted into a boat adapted to the power of the engine, and, after making various experiments, I, in March, 1803 (1802), took on board of the boat at lock No. 20 of the canal, the late Lord Dundas, my patron, and Archibald Spiers, Esq., of Edderslee, and several gentlemen of their acquaintance, and made the steamboat take in drag two loaded vessels, the *Active* and *Eupheima,* of Graymouth, Gow and Espline, masters, each vessel upwards of seventy tons burden, and with great ease they were carried, without the assistance of any horses, through the summit level of this canal to Port Dundas, a distance of 19½ miles. in six hours, although it blew so strong a breeze right ahead during the whole course of the day that no other vessel in the canal attempted to move to windward, and this experiment not only satisfied me, but every person who witnessed it, of the utility of steam navigation."

The proprietors of the canal, however, objected to the use of steamboats, believing that the undulation of the water would wash away the canal banks, and Lord Dundas, who thought differently, was obliged to acquiesce. A model of the steam engine and boat was, however, made for Lord Dundas, and sent to his house in Arlington street, London. It would be interesting to know if this model is still in existence, and where! The boat was laid up in a creek of the canal near Bainsford drawbridge. "While lying here," continues Symington, "Mr. Henry Bell, from Glasgow, who had also

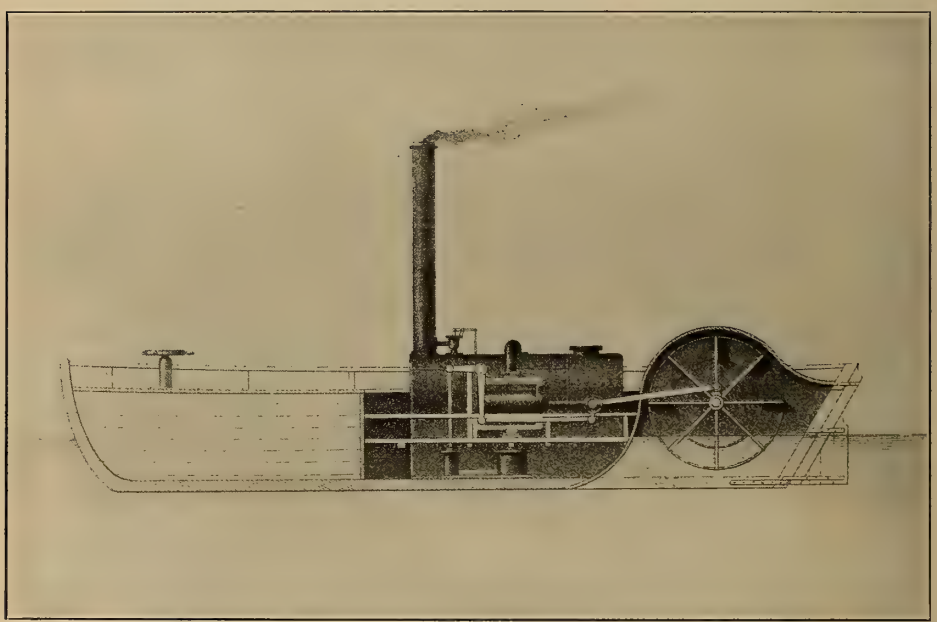


THOMAS, LORD DUNDAS, PATRON OF WILLIAM SYMINGTON.
From the Portrait by Sir Thomas Lawrence at Kerse House, Falkirk, by Permission of the Earl of Zetland.

witnesed my experiments in 1789, was frequently seen to inspect it, and it was this gentleman who, in conjunction with others, constructed in the year 1811, the steamboat the *Comet,* which first plied on the river Clyde. * * * It happened one day during the period that I was employed in conducting the experiments under the patronage of Lord Dundas, viz., in July, 1801, that a stranger came to the banks of the canal and requested to see me. He very politely announced himself as Mr. Fulton, a native of North America, and told me that he intended to return to his native country in a few months, but, having heard of the steamboat experiment, he could not think of leaving the country without waiting upon me, in the hope of seeing the boat and machinery, and procuring some information as to the principles upon which it was moved. He remarked that however beneficial such an invention might be to Great Britain, it would certainly be of much more

importance to North America * * * if he were alowed to carry the plan to North America, it could not but turn out to my advantage, because if I were inclined, or if my other engagements would permit of it, the making, or at least the superintending the making of such vessels, would naturally fall to me."

Flattered by the stranger's attention, and in compliance with his request, Symington caused the engine



THE CHARLOTTE DUNDAS, SYMINGTON'S STEAMBOAT OF 1801

fire to be lit and the machinery set in motion, and, along with several other persons, Fulton was carried from Lock No. 18 four miles west along the canal and back in one hour and twenty minutes, "to the great astonishment of Mr. Fulton and the other gentlemen present." Fulton took notes then of the size and construction of the boat, and questioned Symington on various points. But he never heard further from him, or about him, until his death was announced in the newspapers.

Symington now went to London, and presented his patron, Lord Dundas, with the model of the *Charlotte Dundas*. This afforded an opportunity for his patron to introduce Symington to the Duke of Bridgwater. Symington continues:

"I waited upon the Duke next day, and showed and explained the model to him, when he declared that such a vessel as that before him had every appearance of answering the purposes he wished, and, pointing to his collection of paintings, which he said had cost him upwards of £100,000, he stated his belief that the advantage which trade might derive at some future period from the use of such steamboats would many times exceed the value of his excellent gallery of pictures, and, to show his conviction of the fact, he gave me an immediate order to build eight such boats for the use of his canal, and pressingly requested me to devote my whole time to the executing of this order with as little delay as possible.

Alas for Symington's hopes and prospects, he heard of the death of the Duke of Bridgwater, which can-

celled the order for the steamboats, just about the same time that the proprietors of the Forth and Clyde Canal had decided against the use of them on this canal.

"This so affected me," he says, "that probably I did not use the energy I otherwise might have done to introduce my invention to public notice, and perhaps it was from this circumstance that the introduction of steam navigation was postponed in the United Kingdom of Great Britain 'til after the Americans had taken advantage of it and carried the invention into general practice.

"I was advised to apply for His Majesty's letters patent to cover my invention, which are dated October, 1801, but, after having put myself to this expense, I discovered that the idea of the application of steam to the propelling of boats is much earlier than my time."

This has reference to the patent of Jonathan Hulls, dated 1736, which, however, seems to have been of no practical value, and so Symington concluded, *"I am the first individual* who ever effectually applied the power of the steam engine to the propelling of vessels, without saying anything of my original invention of the *steam carriage.* * * * Much merit is also due to my first patron, Mr. Miller, to whom the country is much indebted for the improvements he made upon the boats and wheels; but it was I alone who invented a steam engine and actually applied it to the propelling of boats."

The names of witnesses to this narrative of facts are, for the

First Boat

Richard Young, gardener, Dalswinton, now grocer, Edinburgh.

Alexander Carlaw, engineer.

Second Boat

Joseph Stainton, Esq., manager, Caron Ironworks.

Henry Stainton, Esq., deputy manager, Carron Ironworks.

William Blaikie, pattern-maker.

James Blaikie, pattern-maker.

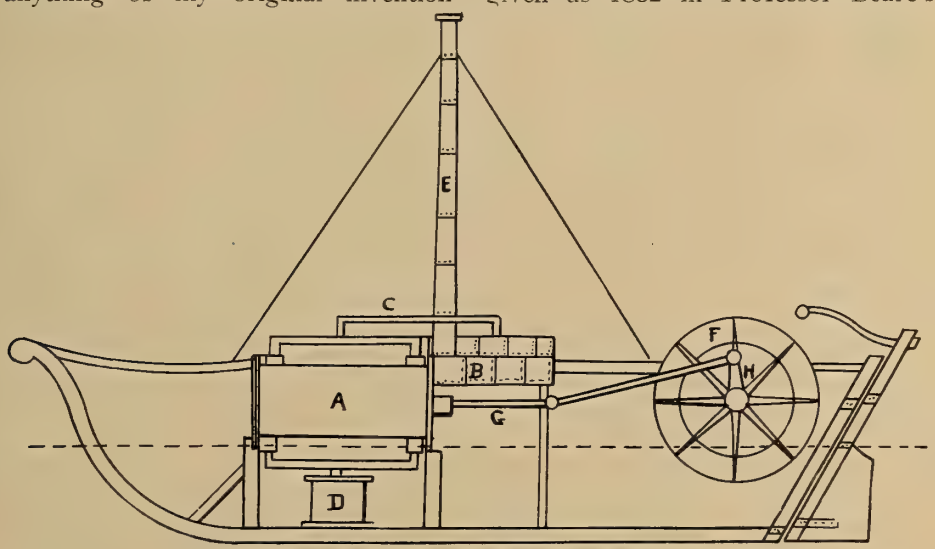
Robert Weir, engine man.

Alexander Hart, ship carpenter, Grangemouth.

John Allan, ship carpenter, Grangemouth.

J. Espline, shipmaster.

Then follows the affidavit of Alexander Selander as to the performance of the *Charlotte Dundas* in March, 1803, already given. This date is given as 1802 in Professor Beare's



ARRANGEMENT OF MACHINERY OF THE CHARLOTTE DUNDAS.

A, cylinder; *B*, boiler; *C*, steam pipe; *D*, condenser; *E*, funnel; *F*, paddle wheel; *G*, piston rod; *H*, crank.

article in the "Dictionary of National Biography."

William Symington, after his hopes were dashed to the ground in connection with steam navigation, tried to protect his patent from infringement by Bell, on the Clyde, with the *Comet,* after 1812, and failed to secure recognition from the Government, as Taylor also had done, save, as before said, £100 from the Privy purse in 1825, and later a sum of £50, but nothing was done for his widow, who resided with her son-in-law, Dr. Bowie, at 74 Bishopsgate Street Within, and later at Burr Street.

In the second volume of "Chamber's Journal," that for 1833, there is a biographical sketch of James Taylor, tutor in the family of Patrick Miller, of Dalswinton, in which he is described as the "originator of steam navigation." It is related that he was in 1787 engaged, along with Mr. Miller, in a sailing match with a party of gentlemen at Leith, in his double vessel, against a first-rate sailing wherry. Miller's vessel won the day, but Taylor, who had a turn at the capstan, found the labour so excessive, that he represented to Miller that unless some more commanding power was employed than manual labour, the invention would be of little use. In thinking over the matter he remembered the use of the steam engine, and successfully combatted Miller's objections to the same. This, it may be allowed, Taylor did, and all this was of the first importance, but that he made the drawings for the steam engine, called in Symington as an engineering mechanic, and superintended its construction, in the face of Symington's own testimony and narrative, given here, is not now so easy of belief. For the first experiments in the Forth and Clyde, Taylor is also said to be responsible, and for the construction of the engine. A patent was never taken out. The article mentions that Lord Dundas was induced by Symington to undertake the experiment of 1801: it was the other way about; according to the engineer's own account, Lord Dundas approached him on the subject. Symington is accused of laying pretensions to the invention, for which he in an underhand way took out a patent unknown either to Taylor or Miller. When remonstrated with by Taylor long afterwards, as to this, Symington penned the following note:—

Glasgow, 9th Feb. 1821.

Sir,

In terms of our former agreement when making experiments of sailing by the steam-engine, I hereby bind and oblige myself to convey to you, by a regular assignation, the one half of the interest and proceeds of the patent taken by me upon that invention, when an opportunity occurs of executing the deed, and when required.

I am, Sir, your obedient servant,
William Symington.

To Mr. James Taylor,
Cumnock.

Mr. John Wight, of Messrs. Wight & Wight, chartered accountants, Glasgow, son of Symington's friend and adviser, in a long letter to ourselves, discussing the whole case, asks why, he being the sole inventor, did he condescend to make such an offer. This letter, Mr. Wight says, is so inconsistent with all Mr. Symington's numerous other letters in his possession, that it nonplussed him to some extent. He came to remember, however, that Symington used the same language to his own father in reference to the reward he would receive should the engineer substantiate his claims. Wight was to be a partner in the concern, and have a substantial interest. But this did not mean to imply on the part of the writer that the person to be rewarded was in any shape or form to be identified with himself as the author of the invention or improvement itself. It only indicated, Mr. Wight thinks, the generous, grateful, courtesy of the man wishing to act rightly by those who had assisted in bringing his invention

into public notice. Taylor had introduced Symington to Miller, and so bulked in his mind as to the person to whom he was under obligation, and whom he desired to recompense. The letter otherwise is absolutely incompatible with all that Symington ever said or did in reference to this subject, from the running of the boat on Dalswinton Loch in 1786 until his death in 1831. "I daresay," concludes Mr. Wight, "Mr. Symington would have persisted rather than surrender a position, and make an admission contrary to what he knew to be true, and contrary also to the whole tenor of his life."

BELL'S STEAMBOAT, THE COMET, ON THE CLYDE IN 1811

Taylor, in 1824, then in anything but prosperous circumstances, drew up a statement as to his share in the origin and progress of steam navigation, which was printed and addressed to Sir Henry Parnell, chairman of the Select Committee of the House of Commons upon Steam Boats, etc. No favourable reply being received, the president of the Board of Trade was appealed to in 1825, with no further success. Taylor passed away in that year, but a third application was more successful in that a pension of £50 a year was bestowed upon his widow, then settled in Edinburgh, and a sum was given to each of her children.

The inscription below the bust of Symington in the Edinburgh Museum of Science and Art claims for him the invention of steam navigation, as does also that on his monument at his native Leadhills. Sir William Thomson (now Lord Kelvin), in unveiling the Edinburgh bust, said that three names were always associated in their minds when thinking of the beginnings of steam navigation, Symington, Henry Bell, and Fulton. He did not believe that Bell and Fulton had ever the slightest intention of being unfair to Symington; he believed that some of their followers and supporters had not been fair to him, but in so far as they had been unfair at all it was through ignorance. Symington was the real discoverer, and the practical originator, the engineer who foresaw that good was to be done, who understood how to make the

machine to do it, and who had the true engineering and mechanical principles for doing it in the right way. Sir R. Murdoch Smith accepted the bust on the part of the Museum, and characterized it as a beautiful and artistic memorial of the designer, inventor, and builder of the first successful steamboat.

Those who consider that James Taylor had anything to do with the invention, might also consider the fact that Symington was an inventor all his life; that the engine for the successful experiment in the Forth and Clyde Canal was made entirely from his plans and under his own personal superintendence, and that Taylor never even visited the Carron Iron Works, where the work was done. Further proof of Symington's inventive faculties comes from the document and letters lately found among the papers of a son of Mr. Robert Wight, his Edinburgh friend and adviser. Some of these, with drawings, were printed in the "Engineer" of April 4, 1902. The most notable is a memorial to the Forth ferry trustees, which contained a memorandum and drawings of a new method for propelling boats across the ferry, dated November, 1814. The first plan shows a boat with common sculling oars, to be moved by a steam engine, cylinder 20-inch diameter, stroke 30-inch long; length over deck 74 feet by 20 feet broad. In a note in Symington's handwriting, it is said that "the above plan took its origin from suggestions of Lord Dundas and Thomas Bruce, Esq., of Grangemuir, by William Symington, Falkirk." Drawing No. 2 shows the plan of a boat with rectangular sculling oars, with revolving blades to be moved by a steam engine, cylinder 20 inches diameter, stroke 30 inches long. Drawing No. 3 shows the stern of the vessel, with the flaps of the oars which open to strike the water with a flat surface, and again fall together when the oar recedes. Drawing No. 4 shows plan of a boat with rectangular sliding sculling oars to be moved by a steam engine, crank 15 inches, cylinder 20 inches, with 30-inch stroke.

This same memorial pointed out the engineer's great inventions, in that he had produced a rotary motion "without the intervention of a lever or beam, or the other apparatus connected therewith." He complains that, although he had taken a patent at the expense of £500, it had been infringed in the case of Bell's *Comet*. He hints that a description of Patrick Miller's paddles sent to "Mr. Washington," then President of the United States, and Benjamin Franklin, accounted for Fulton's success on the Hudson in 1807, which was hardly the case. Two years earlier, Symington forwarded from Falkirk to Wight in Edinburgh the specification of his new steam engine, about which no details are forthcoming. Robert Wight says that Symington never referred to Taylor in terms of disparagement, and on the other hand never referred to him in an opposite sense. Wight and he were one day walking along the shore of the Firth of Forth, between Leith and Portobello, when the former said he had often thought a piece of ordnance might be made of greater utility as an implement of war by loading it at the breach instead of the muzzle, but that he could not see how the thing was to be done. Symington promptly replied that there was nothing in the problem that he could not surmount.

From Mr. James Symington, grandson of the engineer, a working jeweler and watchmaker with Mr. Gilray in Oban, we have obtained some personal and family particulars not generally known, as well as a few gleaned from other sources. Previous to his death, Symington resided with his son-in-law, Dr. Robert Bowie, Burr street, Lower Smithfield, London. Mr. J. A. Lyon, who was a frequent visitor, says he found the engineer a fine, thoughtful, quiet old gentleman, with whom he had many pleasant conversations, mostly with respect to his early inventions and his early life; the

PORTRAIT BUST OF WILLIAM SYMINGTON IN THE EDINBURGH MUSEUM

difficulties he had to contend with; how, when he thought all was going well, Mr. Miller gave up all interest in the invention. He described how Fulton examined his boat at Falkirk, and when he came to England he was going to commence an action against Watt (who tells this the other way about) for an infringement on his patent condensing engine, but found that the same idea had arisen in both their minds without any knowledge of each other. Also, too, when a young man at Leadhills, he had managed to clear a valuable mine of water, where other engineers had failed. His grandson tells a story that, when boring for mineral the borer had snapped, and Symington, by a simple and ingenious means, recovered the broken end and allowed the work to go on. When Symington died a plaster cast was taken of his features after death, which guided Mr. D. W. Stevenson, the sculptor, in the modelling of the Edinburgh bust.

along with a sketch from life by D O. Hill, R. S. A.

James Symington, the Oban grandson, is a man of superior intelligence, excellent character and artistic tastes who, although untrained, paints landscapes and portraits in a way that shows real ability. He says that many a time he has heard his father, a watchmaker at Kingskettle, Fife, speak about the hard position to which he had been brought through William Symington having spent all his time and means in these early steamboat experiments. On one occasion William Symington had been from home for some time, and on his return was asked by his wife for a little money for housekeeping purposes. His answer was, as he threw down his walking stick: "That is all I possess." The engineer had two sons, William and Andrew. William at one time held a good position in the railway service in London, but went to Australia and died there. His son-in-law, Dr. Robert Bowie, with whom his widow resided until her death, and who published a pamphlet in vindication of Symington's memory, also went to Australia, and was governor of a lunatic asylum near Melbourne in 1844. Andrew Symington, the younger son, had to work hard from his earliest years, and as a watch and clockmaker in Kettle, made the town clocks there as well as for many other towns in Fife. One of his sons, William, is in Australia, the other is the Oban watchmaker, and a daughter, Mrs. Dickie (Elizabeth Benson Symington), resides in Glasgow.

A pamphlet published in Ayr in 1834 supported the claims of James Taylor as the originator of steam navigation. Against this we have Symington's pamphlet of 1829 and that of his son-in-law, Dr. Bowie, and all the other testimony we have given. There is a brief biography of Symington by J. and W. N. Rankine, published by A. Johnstone, Falkirk, in 1862, which furnishes all the materials for forming a judgment in the matter; so does J. Scott Russell's "Nature, Properties and Applications of Steam, and of Steam Navigation." Lord Kelvin, Sir R. Murdoch Smith, Prof. J. H. Beare, have all expressed their belief that Symington's claims were genuine. In the paper in "Chamber's Journal" for 1833, which we have mentioned, the sole credit is given to Taylor; in another paper in the March issue of the present year, the credit is unreservedly given to William Symington. The "Engineer," of April 4, 1902, printed an interesting account of Symington's proposals for steam impelled boats, by means of oars, in the Forth ferries. The "Scotsman" of Nov. 14, 1888, and again on March 24, 1902, printed an article which gave full credit to Symington.

The Dalswinton steamboat engine is now in South Kensington Museum. It and the model of the *Charlotte Dundas* were exhibited in Glasgow Exhibition in 1888, along with models of Miller's two boats, the D. O. Hill portrait of Symington, and the cylinder of the steamer *Comet,* made by John Robertson, Glasgow, for Henry Bell.

The hull of the *Charlotte Dundas* lay for many years in a creek of the Forth and Clyde Canal, between locks Nos. 8 and 9, and when broken up various mementos were made of her timbers, one of the most interesting being a chair, now the property of Robert Barr, Arnotdale, Falkirk.

THE SMOKE PROBLEM

By David Townsend, M. Am. Soc. M. E.

The problem of smoke abatement will doubtless continue to demand discussion until it is either completely solved by the abolition of the combustion of solid fuel of any sort, or by the installation of such devices and methods as shall prevent the formation of smoke in the furnace, regardless of the nature of the fuel. It is possible that the production of fuel gas at the collieries, and its transmission to the great centres for combustion, will solve the problem by eliminating it, but until such a change in methods of generating heat and power is realized we shall be dependent upon local installations for the minimizing of the evil. Mr. Townsend rightly calls attention to the fact that the question involves a chemical reaction, and that it should be treated according to accepted chemical methods, and his discussion has thereby added interest.—The Editor.

AMONG the live problems of the day that seem to be forcing themselves on the attention of the world generally, one of much importance is that of the abatement or prevention of smoke arising from the use of soft coal for producing power or heat.

That this question is by no means either recent or modern is proved by the fact that attempts were made to abate smoke as far back as 1661, when it was mentioned in the diary of John Evelyn, of London, who lived from 1620 to 1706, and who gives a minute description of the great London fog of 1684 and its connection with the use of soft coal as a fuel for family purposes.

As far as we have any records, the first smoke-abating invention was patented in 1785 by James Watt, the father of the steam engine. In 1815 Cutler patented the first would-be smokeless house grate, which was afterwards improved by Dr. Neill Arnott, and which improvement was in use for half a century.

In 1819 a committee was appointed by Parliament to consider the question, but nothing much was accomplished, and in 1843 another committee introduced the first bill for the suppression of smoke. Since then there has been much legislation on diverse lines throughout the various municipalities in England and on the continent, there being at the present time a large and influential society in England which devotes itself exclusively to this problem.

This department of the Patent Office is probably one of the most prolific in the number of patents granted exclusively for this purpose, but apparently the practical results are in inverse ratio to the efforts that have been made, for the reason that the majority of the devices patented have aimed to prevent the smoke by mechanical rather than by chemical means.

The smoke nuisance may justly claim pre-eminence in Great Britain, where soft coal is generally cheap and where its use is not confined to industrial purposes, but is universal for house heating by grates and stoves. The accumulation of smoke which naturally results from a city as large as London can be imagined, and one of the reasons for the notorious London fogs is very evident.

If a glass microscope slide is passed quickly over a smoky flame and then examined by a powerful lens, the thin transparent film is seen to consist of numerous small particles of carbon, each particle being surrounded by a coating of oily matter. This explains why fog is not dispersed by rain, as each particle of carbon is practically water-proof, and further explains why smoke sticks so tenaciously to the person, clothing and furniture, producing black smudges. In Pittsburg, Cincinnati and other smoky cities in America it is considered quite proper

to remove soot from the face or person by blowing it vigorously, which sometimes gives rise to misunderstandings when thoughtlessly practiced in places where the custom does not prevail, or on unsuspecting strangers.

The fact might as well be recognized at once that the supply of so-called smokeless fuels, such as anthracite coal, coke, petroleum, natural gas, etc., is limited and cannot begin to satisfy the demand. The supply of bituminous coal, on the other hand, is practically unlimited, and it is doubtless the fuel of the future. Its abundance and cheapness and the readiness with which it burns, even with a poor draft, combine to make it a most desirable fuel. This granted, the further fact remains that it will undoubtedly be burned to a larger and larger extent in all parts of the country and that no legislation can prevent its use. Just as anthracite coal becomes more scarce and its price increases, just so surely will its place be taken by the cheaper and more abundant fuel. The problem before our engineers and lawmakers is not how to prevent the burning of soft coal, but how to burn it in such a way that the combustion shall not create a public nuisance. Unfortunately this, our best fuel, is at the same time our dirtiest, both in the handling and in the burning.

A natural difficulty in the proper consideration of this subject arises from the variety of opinions which always prevail on every subject brought forward for discussion. On the one hand, we have the private citizen who does not believe that manufacturers have any rights which the public needs to respect; and on the other, we have the manufacturer who considers the smoke he is making as an index of the general prosperity, and regards any criticism or interference as malicious persecution.

Between these two extremes are all sorts and conditions of men; some belligerent, some indifferent, some interested, but nearly all destitute of any appreciation of the true nature of smoke or the means for its abatement.

There are three undeniable propositions in regard to smoke that may be stated as:—

First, it is a nuisance; second, it can be modified or entirely eliminated; and third, that such elimination is a source of profit to the owner of the plant, as well as to the community at large.

In law a nuisance is defined to be "such a use of property or such a course of conduct as, irrespective of actual trespass against others or of malicious or actual criminal interest, transgresses the just restrictions upon use or conduct which the proximity of other persons or property in civilized communities imposes upon what would otherwise be rightful freedom."

Smoke is a nuisance which I have no more right to inflict upon my neighbor than I have to empty my garbage can over the fence into his yard, and as such is a perfectly legitimate subject for regulation by law.

The Century Dictionary defines smoke "as volatile matter thrown off in the form of visible vapour as the product of combustion"; but I should rather expect the housekeeper to define it as dirt that floated in the windows and spoiled the curtains and carpets.

All bituminous coal is composed of varying quantities of carbon, volatile matter, with some sulphur, moisture and earthy matter or ash, the percentage of carbon varying from 90 per cent. in West Virginia Pocahontas coal to 60 per cent. in Texas lignite.

The volatile matter, composed principally of carbon and hydrogen, is driven off as gas when heated to a comparatively low temperature, and escapes unburnt, producing the heavy black smoke which is so objectionable. If the hydrocarbon is heated to a sufficiently high temperature in the presence of the proper quantity of air, it will unite with the oxygen in the air and burn to a colourless gas,

known as carbon dioxide. If the air supply is insufficient, or is poorly mixed, or the temperature is too low, combustion is checked and carbon is deposited in the form of soot, or carried into the air as smoke.

The ordinary coal-oil lamp is one of the best illustrations of perfect combustion and consequent smoke prevention. The heated gases rising in the chimney produce a draft and fresh air is continually drawn in at the bottom through the hot gauze which warms and divides it so as to insure thorough mixing with the gases from the burning oil. Turn up the wick and the flame becomes smoky—too much hydrocarbon for the air supply. Raise the chimney slightly from the bottom and again there is smoke—too much air at too low a temperature, which chills the flame. Insert a cool metal rod into the chimney and soot is deposited on it—chilling of the flame again and disengagement of the carbon, while the hydrogen continues to burn.

The actual amount of smoke in the air has been largely increased on account of the unprecedented prosperity of the last few years, and there is hardly a manufacturing plant in the country that is not short of boiler capacity, necessitating the forcing of combustion by some mechanical means, and, as a matter of course, increasing the waste of fuel and production of smoke.

Under the very best mechanical conditions obtainable in ordinary boiler practice only about 70 per cent. of the theoretical heat or efficiency in the fuel is utilized, and in many antiquated or worn-out plants only 50 per cent. of the heating value of the coal is used, the balance escaping into the air as smoke or being otherwise lost on account of imperfections in the equipment.

The question of what penalties should attach to a smoke ordinance, of course, depends largely on the ability of the offenders to procure suitable means or appliances with which to accomplish the result.

It is practically impossible to secure perfectly smokeless combustion in any ordinary furnace fired by hand, under the usual conditions of natural draft as existing to-day in the majority of plants. Some device is therefore necessary to accomplish this result. There have been innumerable appliances devised to consume or prevent smoke, but nearly all of these aim to do so by purely mechanical means, with usually indifferent results, because the fundamental laws governing combustion are chemical laws rather than mechanical principles.

The usual solution of the smoke problem, so far, has come from the introduction of mechanical means of handling the coal, which gives a uniform feed to the fuel and a correspanding delivery of air for combustion. The use of mechanical stokers has been brought about by the mutual demand for machine handling in large power plants as more economical than human labour, rather than by a philanthropic desire to benefit the community. It has been estimated that one able-bodied man with a shovel and slice-bar can take care of 200 horse-power of boilers. With good mechanical stokers he can handle double, and with complete coal and ash-handling equipment, three times this amount.

Stokers may be divided into three general classes: inclined shaking grates, travelling or chain grates, and under-feed stokers. The inclined grate has a hopper in front and slopes down and back, having a clinker grate just in front of the bridge wall; while the double incline has a magazine on either side and slopes in two planes parallel to the axis of the boiler, meeting in a clinker grate at the bottom. The principle of action is practically the same and involves the slow coking of the coal on a dead plate, the pushing forward on the top of the incline and the gradual descent, impelled by oscillation of the grate bars, until the combustion has left nothing but ash and clinker at the bottom. Air is usually admitted both

below and above the grate, and the hydrocarbons which are distilled at the top of the grates pass through the intense heat of the burning coke on their way to the bridge wall. The double incline usually has a revolving clinker bar which disposes of some of the ash automatically, but as a rule both forms need considerable cleaning. When used with a fuel which does not cake or clinker too much, and when not crowded too hard, these stokers reduce the amount of smoke considerably. If, however, it becomes necessary to slice and poke the fire, on account of caking coal or overcrowded boilers, unburned masses of coal are rolled to the bottom and holes are made in the fire through which cold air rushes. Both of these circumstances make for poor combustion and a smoky fire. As a rule, firemen poke the fire on stokers too much, doing more harm than good.

The under-feed stokers operate on an entirely different principle, the coal being fed in underneath the grate and forced up through the rectangular opening in the center. A forced blast is used and the air for combustion is blown up through the coal, the tuyeres being on either side of the rectangular opening just mentioned. By this arrangement the fresh coal is always underneath and the distilled gases are obliged to pass through an incandescent mass of fuel in company with the air. The ash and clinker are now at the top of the fuel, which forms a gradual rising mound in the center and pushes the clinker over to either side, whence it is removed by hooks through doors at the front. The heat generated is such that the ash generally melts and forms a sheet of clinker which can be removed without disturbing the fire.

In the American stoker the coal is forced under the grate and up by a revolving screw, somewhat similar in shape to the ordinary gimlet-pointed lag screw. In the Jones underfeed stoker a plunger driven by steam operates to feed the coal. This plunger can be arranged to start and stop by hand or to run automatically.

Another method, and one which is apparently based upon correct chemical principles, is that known as the Cornell economizer, this system utilizing the waste heat passing over the bridge wall to dissociate a small amount of steam to oxygen and hydrogen in cast-iron retorts, the resulting gases being passed through the fire and furnishing oxygen to combine with the otherwise unburned carbon and hydrogen to burn itself in the furnace. The presence of oxygen renders it unnecessary to have an excess of air, and thus prevents the chilling of the furnace, while the proportions may be made such as to effect practically a complete and smokeless combustion, independently of the method of firing the solid fuel.

The economy resulting from the abatement of smoke is naturally a potent argument in its favour. This phase of the subject has, however, little to do with the ethics of the question, as every community has a right to insist on its abatement regardless of economical considerations.

As a general proposition smoke consumption means economy of fuel, as it is the result of perfect combustion and the combination of carbon and oxygen to form a colorless, unburnable gas. Of course, it must always be remembered that a smokeless chimney does not always mean economy, as an excess of air may dilute the chimney gases sufficiently to cause a serious waste of heat.

The problem can best be scientifically studied by carefully watching the chimney gases as to their temperature and chemical composition, and by making such a disposition of forced drafts or dampers, together with the best smoke consuming appliances as will insure the best results. In the Cornell economizer, which has already been mentioned, a saving in fuel of 28 per cent, has

been effected in tests made by engineers of the United States Government, and a positive guarantee is made of 15 per cent. saving, or a proportionate increase in boiler capacity, when the boilers are run to their full rated capacity, in addition to a guarantee to eliminate smoke. The only sure method of determining the value of any smoke device is to run a regular United States standard blow-off test before applying any apparatus and then immediately after doing so, and absolute scientific data will be obtained of both the fuel economy and smoke consumption.

This brings us to the question of regulation by law and it is on this point that the world at large is just waking up to its rights in the premises.

In the matter of property damage alone it is difficult to form any close estimate of the damage inflicted on the business community by reason of soft coal smoke.

The deterioration of dry goods, draperies and delicate fabrics on the shelves and counters and in the show windows is a direct tax on the buyer. I am told that one of the largest items of annual expense in city hotels and club houses is the cleaning and refurnishing of rugs, curtains and furniture and redecorating walls and ceilings.

The presence of more or less sulphur in the soot renders it a corrosive as well as a discoloring agent and greatly increases the damage done to buildings, marble facings, steel stacks, etc.

Trees and shrubs suffer also in such an atmosphere, and are frequently killed outright by the presence of sulphur in the smoke; and I leave it to other, more competent than I, to determine the amount of injury sustained by the human body in both health and disease by being compelled to take into the throat and lungs an oxydizing agent so thoroughly contaminated by deleterious substances.

There is probably not a large city in the United States that does not have some kind of smoke ordinance in force, but until a very recent date these laws have been practically a dead letter.

The principal difficulty in the rigid enforcement of any local ordinance lies in the fact that City Councils have no authority to pass ordinances containing penalties which would deprive delinquents of their personal liberty, as that is generally a province of the State Legislature alone.

No ordinance can be made effective unless some penalty involving the personal liberty of the delinquent is attached, in addition to heavy monetary fines advancing in amount with each offense.

One of the best local ordinances not only provides for a graded fine for persistent delinquents who own or operate plants, but also provides for the arrest of all persons having in their control the actual operations of such plants. This may seem rather unfair to the man behind the shovel, but when you have been up against the proposition of having installed a smoke consuming device at considerable expense and it is improperly or carelessly operated, it seems only just that persons who are actually responsible for making the smoke should bear part of the penalty for doing so.

Remedial legislation, both by State and municipality, is being adopted almost universally throughout the most thickly settled portions of our country, but unfortunately it is not being done with any uniformity or with due regard to the rights of the owner and of the public, in many cases it being so stringent that its enforcement is impossible, and in other cases so mild and the law so loosely drawn that it fails to accomplish the desired results.

ELECTRO-MAGNETS FOR LIFTING AND HANDLING MATERIALS

By Charles R. Benjamin

SOME things which are useful—a wheelbarrow for instance—appeal to our practical sense alone. The lifting magnet appeals to the imaginative sense as well. It is difficult to enthuse over a wheelbarrow (necessary as it is in some lines of work), but a lifting magnet in action seizes on the imagination, and quite apart from its manifest utility, it leaves on the mind of the observer a distinct impression of wonder, akin to that first felt when as a youngster he gazed open-mouthed at the miracles performed by his first horseshoe magnet.

Writers of popular magazine articles have compared the lifting magnet to the hand of a giant, and the simile is not inapt, for the work accomplished by one of these modern time-savers is truly gigantic. A 10-ton "skull-cracker" is picked up by a lifting magnet as easily as a child picks up its rubber ball. Cars laden with pig iron the magnet unloads in a few hours, whereas days were formerly required for the same work, when done by hand.

Watching what is known as a "pig magnet" at work, the paramount impression is one of power, but no less impressive are "plate magnets," for these, while seldom called upon to lift great weights, exhibit what, in speaking of animate objects, would be described as a higher order of intelligence. The plate magnet is used for lifting and transporting metal in sheets, and the impressive thing about this class of work is that the same magnet will pick up the plates one, two or three at a time, or will seize on an entire pile and distribute the plates about the shop singly, or in twos or threes, as a euchre player deals cards. This is accomplished by regulating the amount of current taken by the magnet so as to increase or diminish its tractive force.

Structurally considered, a lifting magnet consists of a copper coil imbedded in an outer casing of cast-iron or steel. They differ in size and form. Pig magnets, which are used for handling pig iron, scrap metal and similar material, are usually circular in form and range from 35 to 50 inches in diameter. Plate magnets, which are used for handling metal in sheets or bars, are, as a rule, smaller, and in shape are generally rectangular, though for certain kinds of work the circular form answers quite as well. All lifting magnets are electro-magnets, that is to say they depend upon an electric current for their energy and are "dead" when deprived of it. This characteristic is, of course, essential to their success commercially, for if the magnetism was constant, as in the lodestone and the horseshoe magnet of boyhood days, the lifting magnet would pick up its armature (the technical name for the object or objects to be lifted), but would not release it unless compelled to do so by a physical force superior to the pull exerted by the magnet itself.

The magnetic qualities of the lodestone have been known from time immemorial, a fabulous mountain of magnetic ore which drew the nails out of passing ships being the theme of one of the stories in that ancient classic—The Arabian Nights. The fact that iron and steel can be magnetized by means of an electric current is a modern discovery, dating

MAGNET LIFTING 2,080 POUNDS OF PIG IRON AT DONORA WORKS OF THE CARNEGIE STEEL CO. CUTLER-HAMMER CO., MILWAUKEE, WIS.

back only to the early part of the last century. It was not until a dozen years ago, however, that this knowledge was utilized by inventors seeking a method of handling iron and steel more economically, and even as recently as 1901 a writer in *The Scientific American,* referring to the lifting magnet, described it as "one of the *newest* and most ingenious devices for the speedy and economical handling of material in great manufacturing plants." The manufacture of lifting magnets may therefore be said to be an infant industry, and the fact that the number of commercial magnets in use in the United States to-day is comparatively small (taking into consideration the immense number of plants in this country which could profitably employ them for handling various forms of raw metals and finished parts) is doubtless in large measure due to the fact that the advantages of lifting magnets are not yet generally realized. It is significant that no establishment that has tried the lifting magnet has ever returned to the old method of handling iron and steel, and it is safe to say that at no very distant date the lifting magnet will be considered as indispensable as that other labour-saving device with which it is associated—the electric crane.

Wherever pig iron, metal plates,

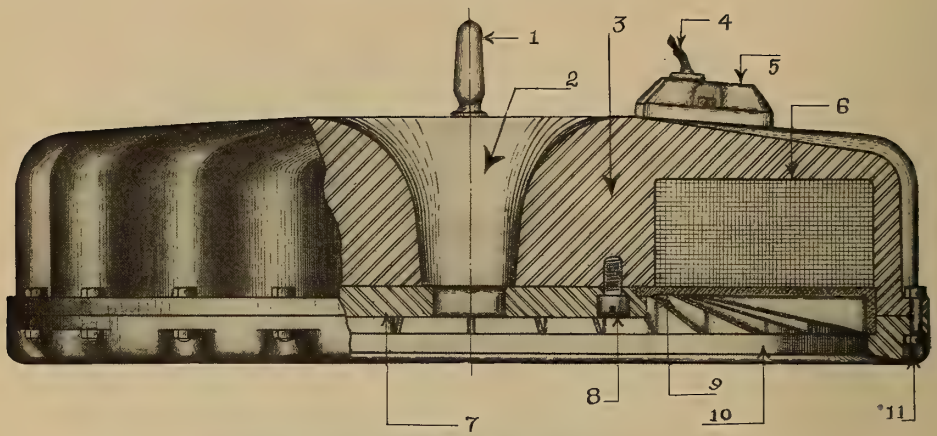
MAGNET LIFTING STEEL STAMPINGS, SHOWING THE SUPERIOR ATTRACTION OF THE INNER POLE

tubes, rails, beams, heavy castings of iron or steel, or the scrap of these metals are handled, lifting magnets can be advantageously employed. The time saved, due to the fact that the use of a magnet eliminates the necessity of adjusting hoisting tackle to the object to be raised, is oftentimes of itself sufficient to justify the installation of a lifting magnet. Particularly in the case of pig iron and scrap metal are the practical advantages of the magnet obvious, owing to the large number of pieces that can be handled at a single lift, and to the fact that the pieces so handled need not be piled beforehand. All that is necessary in work of this sort is to lower the magnet on to the pile of pigs or scrap, switch on the current—and lift. A further advantage of lifting magnets, and one that has led to their installation in many foundries and blast furnaces, is found in the fact that metal too hot to be touched with the fingers can be handled with a magnet as easily as cold metal. Castings which, because of their shape or because of unequal distribution of weight, require careful adjustment of hoisting tackle, and finished parts which would be liable to be chafed with chains, are examples of objects that can be more conveniently handled with lifting magnets than in any other way. Armor plate and thin sheets of iron or steel used in the manufacture of pressed steel or iron ware, tubes, rails, and a multitude of other finished or raw products forming part of the iron and steel industry are all capable of being expeditiously and economically handled by lifting magnets. The single limitation to the magnet's field of usefulness is, in fact, that the objects to be handled shall possess magnetic qualities. Brass and copper are non-magnetic metals and cannot be handled with lifting magnets.

The anatomy of a lifting magnet is comparatively simple. The largest single piece is the body. This is usually a circular casting of iron or steel, hollowed on the inside to receive the magnetizing coil, and corrugated on the outside in order to secure the greatest possible surface area for heat radiation. This is one of the most important points to be considered in the design of lifting magnets, and will be referred to again presently. The coil—on the design and construction of which the efficiency of the magnet depends to a greater extent than on any other sin-

A 10-INCH MAGNET LIFTING THREE TANK HEADS

CUTLER-HAMMER MAGNET HANDLING MACHINE-CAST PIG. A 50-INCH MAGNET WILL LIFT ABOUT A TON OF THESE AT A TIME



STRUCTURAL VIEW OF THE CUTLER-HAMMER LIFTING MAGNET

1. One of three eye-bolts. 2. Central flue permitting heat to be radiated through body of magnet. 3. Magnet body. 4. Leads. 5. Terminal box. 6. Coil. 7. Inner-pole shoe. 8. One of the inner-pole shoe retaining screws. 9. Coil shield. 10. Outer-pole shoe (removable). 11. One of the through bolts holding removable outer-pole shoe.

gle feature—is invariably of copper. Every manufacturer of lifting magnets has his own ideas regarding the manner in which the coil should be made, but all have the same object in view, namely, to secure the greatest possible amount of magnetization with a given amount of copper. Very little reliable data on this point being available, it follows that each manufacturer of lifting magnets constructs his coil in the light of his own experience; and upon the extent of his knowledge of the established laws of electro-magnetism and his ability to deduce accurate conclusions from phenomena as yet imperfectly understood the efficiency of his magnet depends. No single feature of a lifting magnet is quite so fruitful of discussion as coil construction, nor can one readily conceive of a discussion more bewildering to the uninitiated. Fortunately, for himself, the purchaser of a lifting magnet is usually a person of a practical turn of mind, whose sole interest in the matter is to secure the magnet that will handle the pig iron plates, or other material to be moved, most economically and expeditiously. Hence, he is seldom influenced by technical dissertations, but is interested only in the lifting capacity.

Every lifting magnet has two poles —an inner pole and an outer pole. The inner pole is that portion of the magnet body which lies within the magnetizing coil; the outer pole, that portion which lies without. This will be more readily understood if one remembers that a circular magnet is simply an infinite number of horseshoe magnets. Imagine one leg, or pole, of a horseshoe magnet fastened to the corresponding leg, or pole, of a second magnet so that the two horseshoe magnets will approximate in form a lower case **m**. Imagine now that a dozen other horseshoe magnets are stood up beside these two so that the inner legs, or poles, of all are in touch, and finally, imagine that in the spaces between these magnets other magnets are wedged in—the ultimate result would be a circle of magnets. A circular magnet is simply this circle of magnets welded together, and the proof of this is that a cross section of any circular magnet gives us two horseshoe magnets standing side by side. The legs, or poles, that were innermost when the horseshoe magnets were arranged in a circle unite to form the inner pole of the circular magnet, and, similarly the outermost legs, or poles, unite to form the outer

pole. In the resultant gap between the two poles we have the space in which, in electro-magnets, the coil is placed (being slipped over the inner pole as a ring is slipped onto one's finger), while the arched portions of the horseshoe magnets form collectively the body of our circular magnet.

It will be noted from this description that the poles are nothing more than the downward extension of the magnet frame, or body. Above the coil the body and poles form one piece, but viewed from the under side the poles are found to be separated from one another by the annular depression in which the coil is placed. After the coil is inserted this gap is bridged by a brass ring—the coil-shield—placed between the two poles—inner pole, coil-shield and outer pole forming the under surface of the magnet. We have, then, for the under surface of the magnet two rings of magnetic material (iron) separated by a ring of non-magnetic material (brass). If the coil shield were of iron also, instead of brass, then the magnetic circuit would be complete, and when the magnet was energized by the admission of an electric current to the coil the resultant flux, or magnetic lines of force, would find a pathway already provided for them from pole to pole. But the brass plate on the under side of the magnet offers an impediment to their passage in that direction, and since they must go on they leap from one pole to the other.

Like forceful men, the forces of nature accomplish most when most opposed. The river that flows unhindered to the sea grinds no grist. Given an uninterrupted circuit, an electric current is non-productive. To make it yield power, or light, or heat, you must oppose it. So with the magnet's lines of force. If a pathway is provided for them they will take it and seek no other; but checked in their career they fly through space from pole to pole, thus permeating the atmosphere adjacent to the under surface of the magnet with the magnetic flux, or lines of force.

In endeavoring to give concrete form to these invisible lines of force, writers on electro-magnetism have adopted various analogies, the most common of which is to conceive of the lines of force as streams of water flowing from pole to pole. For our purpose, however, it will perhaps be better to think of these lines of force as a multitude of thin wires stretched from the inner to the outer pole of the magnet. Remembering that a circular magnet is merely an infinite number of horseshoe magnets arranged in the form of a circle, and that the cross section of a circular magnet gives us two horseshoe magnets standing side by side, let an inverted letter U (∩) stand for one-half of the cross section of a circular magnet. Draw with a pencil as many lines as you can from one extremity of the ∩ to the other. The first may be a straight line; the second must necessarily curve a little; the third a little more, and so on until the last line of all will be approximately semi-circular. These pencil lines represent the lines of force. It we think of them as wires and remember that in their passage from pole to pole they penetrate any object of iron or steel introduced in their path, we shall see a mental picture of a mass of metal suspended on these wires, or lines of force, and crude as is the analogy it serves to illustrate with some degree of accuracy the manner in which the lifting magnet supports its load. It also helps us to understand why the ideal load for a lifting magnet is a solid mass of metal. Suppose (the figures given are arbitrary) that in a lifting magnet of given size there are 700,000 of these lines of force passing from pole to pole, and that each of these lines is capable of supporting the weight of a single grain, avoirdupois. Then (since there are 7,000 grains to the pound) 7,000 of these lines will support one pound and the whole number of lines of force (700,000) will

support a hundred pounds, provided all of them can penetrate the load to be lifted. If, however, the load consists of various pieces of metal, instead of a solid mass, then there will be spaces between the various pieces and some of the lines of force will pass through these instead of through the metal constituting the load, and will contribute nothing towards the support of the load. The total number of lines of force passing from pole to pole may be the same as before, but the efficiency of the magnet will be less because, owing to the nature of the load, fewer lines will penetrate the metal to be lifted. This explanation, it should be noted (like the analogy of the wires strung from pole to pole), is at best a feeble attempt to picture graphically the operation of an invisible force. The result necessarily leaves much to be desired.

MAGNET USED BY YOUNGSTOWN SHEET AND TUBE CO., AND WHICH UNLOADED 109,350 POUNDS OF PIG IRON IN 2 HOURS AND 5 MINUTES

So powerful are the lines of force of a 50-inch magnet that they will sustain the weight of a solid mass of metal weighing as much as 10 tons. If the load presented consists of a number of small pieces—such as iron pigs, for instance—the magnet (as has already been explained) will not pick up so much. One thousand to three thousand pounds of pig iron is a good lift for a 50-inch magnet, and even these weights will not often be attained except by an exceptionally good magnet operating under favorable conditions. The efficiency of electro-magnets depend upon so many contingencies that no manufacturer of lifting magnets can guarantee that his magnet will invariably handle a given number of pounds. Impurities in the metal constituting the load, inequalities of surface, the proximity of other magnetic material to the objects to be lifted—these and many other conditions tend to influence the lifting capacity of the magnet.

Some idea of the normal efficiency of a 50-inch "pig magnet" operating under service conditions may be obtained from records of tests. In large plants manufacturing iron and steel products many lifting magnets are employed for handling pig iron, scrap, etc. It is customary in these plants, when a new magnet is needed, to invite magnet manufacturers to submit one of their lifting magnets for test, the record made by each being carefully noted, and the magnet making the best showing under actual service conditions being purchased. A test of this kind (the most recent of which the writers have any knowledge) was lately made at the works of the Youngstown (Ohio) Sheet & Tube Company. The successful magnet was one made by the Cutler-Hammer Clutch Company, of Milwaukee, which developed an efficiency 40 per cent. greater than that of the next nearest competitor. One man—the crane operator—using the Milwaukee magnet, unloaded a steel gondola containing 109,350 pounds of pig iron in two hours and five minutes. The average weight of metal moved, per lift, was 789 pounds. The current required to energize the magnet was 30 amperes at 220 volts.

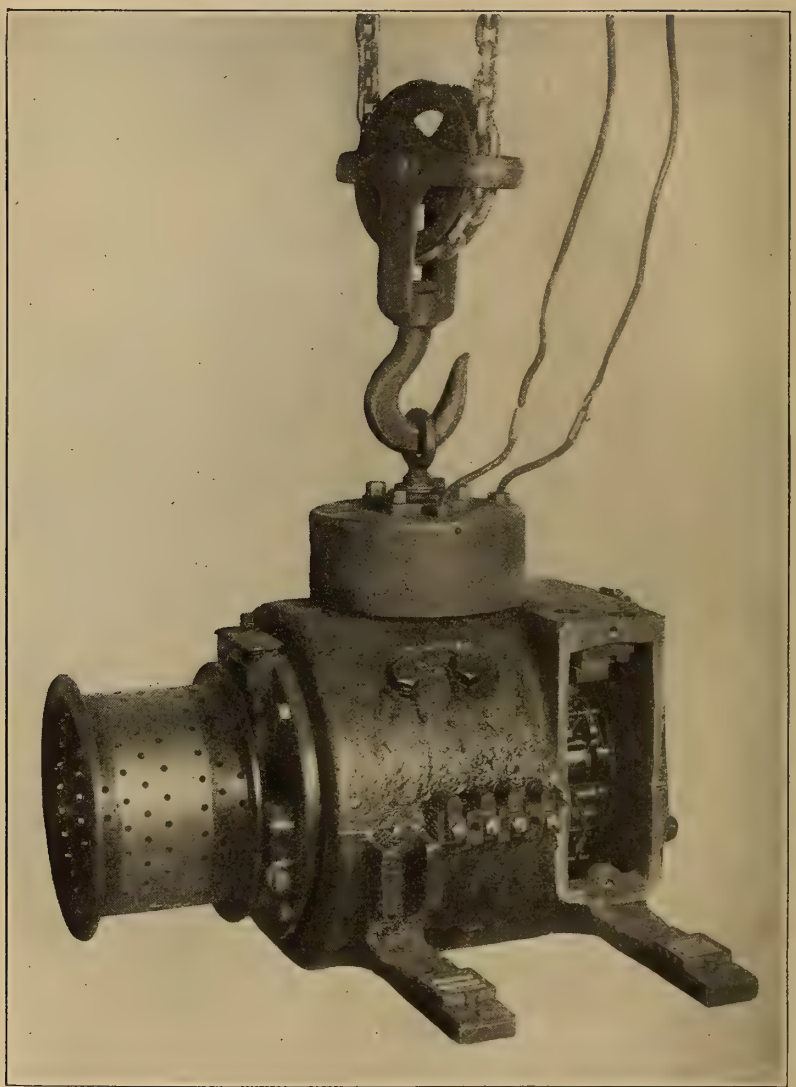
The cost of current consumed by the magnet during the period required to unload the 54 tons of pig iron was less than 25 cents.

In the test just described, the fact that the metal to be moved was contained in a steel receptacle—the gondola—tended to decrease the normal efficiency of the magnet. A similar magnet, built by the same company for the Carnegie Steel Company's Donora Works, is shown in action in some of the accompanying illustrations. One of the photographs shows this magnet handling 32 sand-cast, manganese iron pigs, averaging 65 pounds each in weight—a total lift of 2,080 pounds. In another view it is shown lifting a 5,500-pound "skull." The 10-inch magnet shown, while designed for handling plates, tank heads, and other comparatively light material, will readily pick up a casting weighing 3,000 pounds or more—all of which verifies the statement previously made, that the efficiency of a lifting magnet varies with the nature of its load.

MAGNET LIFTING 5,500-POUND SKULL. CUTLER-HAMMER CO.

Like most other inventions, the lifting magnet has passed through a number of stages of development. A dozen years ago it was frankly admitted to be an experiment, and pictures of early forms of commercial magnets differ in many particulars from the lines of more recent constructions. With the adoption of the "mushroom" shape for circular magnets, however, the form of this class of magnets seemed to be fixed. That even this form was susceptible of improvement has been demonstrated lately by the manufacturers of the Milwaukee magnet, which is the most recent of any in design and may be fairly taken as representative of what is newest and best in lifting magnet construction. This magnet is the result of careful study by engineers who for many years have devoted themselves exclusively to problems involving electric and magnetic control, and as it embodies features which are radical departures from the hitherto accepted designs for lifting magnets, mention of some of them will probably be of interest even to those who are well acquainted with older forms of magnets.

Viewed from the top the Milwaukee magnet is at once seen to differ from all other lifting magnets in that a circular aperature is cored clear through the center of the magnet body. If levity were permissible in speaking of so weighty a subject, one might be tempted to describe this magnet as the first lifting magnet made like a doughnut. Magnet bodies have sometimes been cast with a slight depression in the center in order to obtain a uniform cross section and to eliminate useless metal, and one's first impression is apt to be that the center of the Milwaukee magnet is cored for the purpose of reducing its weight. While, as a matter of fact, a saving of several hundred pounds is obtained by this novel form of construction, the central aperature subserves a more vital



CUTLER-HAMMER 10-INCH MAGNET LIFTING 800-POUND GENERATOR. WEIGHT OF MAGNET 75 POUNDS

purpose. Reference has already been made to the importance of heat radiation in lifting magnets, and attention has been called to the fact that all circular magnets of large size are made with corrugated frames for the purpose of providing a greater superficial area for the dissipation of heat. Hitherto, however, "pig magnets," which are made with concave faces, have been open to the objection that a pocket of dead air forms in the concavity of the under side of the magnet tending to increase the working temperature of the magnet body. This objectionable feature is eliminated in the magnet under consideration by the simple expedient of providing a flue so that air may circulate through the body of the magnet. Another unique feature of this same magnet is the removable pole shoe. It will be readily understood that the under side of a lifting magnet is the

part subjected to the greatest wear and tear, since it is continually being hammered with the metal handled. The makers of the Milwaukee magnet have therefore shod their magnet with a removable shoe which can be cheaply renewed.

The fact that in this magnet the attraction of the inner pole has been purposely made stronger than that of the outer pole is also worthy of mention. The practical effect of this concentration of the magnetic flux on the inner pole is that in handling pig iron, scrap, or similar material, the various pieces constituting the load are released by the outer pole first, when the current is switched off, and in falling are drawn towards the center of the magnet by the superior attraction of the inner pole, thus enabling the operator to deposit the load within the area scarcely exceeding in radius the diameter of the magnet itself. This ability to drop the load within a restricted area is sometimes most important, as for instance, when lifting magnets are used for charging cupolas.

In conclusion, allusion should be made to the effective use made of the central flue already described by the insertion in it of a yoke supporting an auxiliary pole piece, reference being had to the accompanying diagrams for a better understanding of the matter. Lifting magnets of large size designed for use with pig iron, scrap, etc., are made concave on the under side because this form is best adapted for handling large numbers of irregularly shaped pieces at a single lift. When, however, the load consists of one or two large objects with plane surfaces, this concavity becomes objectionable, since an air gap intervenes between the inner pole and the object to be lifted. An auxiliary pole piece supported by a yoke fitting into the central aperature of the magnet and so proportioned as to extend the inner pole downwards to the level of the outer pole, overcomes this difficulty and insures intimate contact of both poles with the object to be lifted.

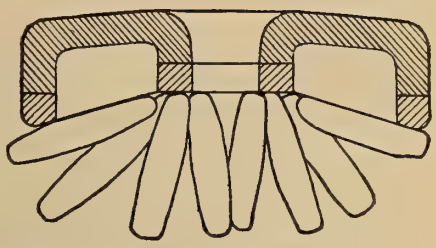
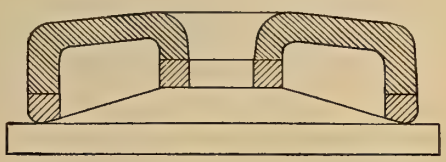
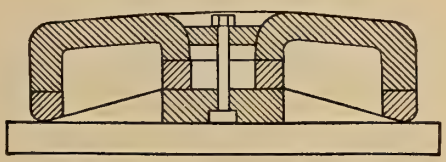


DIAGRAM SHOWING ADVANTAGES OF CONCAVE-FACED MAGNET FOR LIFTING PIG IRON



BUT THE CONCAVE FACE IS NOT WELL ADAPTED FOR INGOTS, PLATES, ETC., BECAUSE OF DISTANCE OF INNER POLE



BY MEANS OF THE AUXILIARY POLE PIECE THIS DIFFICULTY IS OVERCOME

Current Topics

IN Mr. Robert Cochrane's interesting account of the work of Symington in the early development of steam navigation, elsewhere in this issue, there are some points which may be considered as open to discussion in the hope that apparent discrepancies may possibly be cleared up.

Symington, in his own narrative, undoubtedly considered himself as the "first individual who ever effectually applied the power of the steam engine to the propelling of vessels." In so saying, he evidently considered Hulls as the only possible predecessor, and it is probably true that the steamboat of Hulls existed on paper only, and that he never built a working model. Indeed, it is hardly possible that the single-acting atmospheric engine, as it existed in 1737, could have been applied to give practical operation to the crude combination of wheels and ratchets shown in the design of Hulls. There is no doubt, however, that Fitch had built an operative steamboat in America as early as 1786, but it is probable that Symington knew nothing of this, nor of the later experiments of Fitch.

So far as the question of the relation of the work of Fulton to that of Symington is concerned, there appears to be a confusion of dates. Symington, in his narrative, states that Fulton visited him in July, 1801, and then saw the *Charlotte Dundas*. It is probable that this was not in 1801, but in 1802. It is a matter of official record that in July, 1801, Fulton was at Brest, engaged in his demonstration of torpedoes and submarine navigation before the French Commission; and he actually made descents in the *Nautilus* there in June and July of that year, being actively engaged in this absorbing work from June to August. As France and England were then at war, it is hardly probable that Fulton visited England until after the peace of Amiens, in March, 1802, but it is extremely probable that he did come to England at that time, as he was then preparing for his experiments in steam navigation on the Seine, and was arranging with Boulton and Watt for the steam engine. As Symington himself dates his successful experiments on the Forth and Clyde Canal in 1802 and 1803, these facts all indicate a slip in the date of the visit of Fulton, and suggest that it was in 1802, and not in 1801 that he saw the *Charlotte Dundas*. As war was again declared in the spring of 1803, it is hardly probable that the visit was made in that year, although Fulton did visit England in 1805, and was there during the greater part of 1806, but this was after Symington's experiments had been abandoned.

IN the Railway Section of the Engineering Conference at the Institute of Civil Engineers, a highly interesting paper was given by Mr. H. R. A. Mallock, F. R. S., upon "The Action Between Wheel and Rail." It is probably within the knowledge of all readers of CASSIER'S MAGAZINE that the rapid and totally unexpected wear of the rails has developed into a matter of the greatest importance in connection with the maintenance of Metropolitan Tube Railways. Mr. Mallock's investigation, which is commendably practical, proceeds somewhat upon the following lines:—

Suppose a wheel carrying a load of 4 tons, and that wheel and rail will each bear a load of 20 tons per square inch before deformation, there must evidently be more than a fifth of a square inch of contact between rail and wheel if crushing is not to take place. Mr. Mallock shows that in practice it must not be more than 0.3 square inch, and in order to do this a 5-foot wheel, if the width of tread be assumed as 1 inch, is necessary. Taking a 40-inch wheel as an example, the permanent deformation produced by its passage carrying a 4-ton load over a rail with an inch-wide contact is a very minute quantity indeed, viz: five one-millionths of an inch. Negligible, in fact, one might say, but supposing a 2-minute service of trains for 12 hours daily, each train being made up of six eight-wheeled carriages, this rate of wear would amount to 2.6 inches per annum. If now the width of contact were increased to anything over 1.4 inch, this wear due to crushing or deformation would cease, the practical outcome being a suggestion that the rail-section should be modified to give a greater area of contact.

Another source of wear is slipping, which we know takes place extensively on curves, and, to a less degree, on the straight. Mr. Mallock considers that the ripple-like marks often seen on rails over which small wheels run are due to slip: and, incidentally mentioning that the wave length or period of these ripples is $2\frac{1}{2}$ to 3 inches, goes on to suggest that it may be found to coincide with the period of torsional vibration of two wheels of slightly different diameters mounted on the same axle. If you attempt to use a turning-tool upon a disc or wheel mounted in a lathe without due regard to rigidity, what is called "chattering" will ensue, and this effect produces miniature ripples in the surface of the work of a character very similar to those above mentioned.

ON the question of the chemical composition of steel rails and latest developments, the veteran Mr. C. P. Sandberg stated that he saw no reason to modify the opinion expressed in a paper read by him nearly forty years ago that no universal specification or composition for rails could be satisfactorily arrived at. After discussing the effects of the elements, phosphorus, sulphur, manganese, silicon and carbon, contained to a greater or less proportion in various specifications for steel rails, he went on to advocate cold-rolling of the rail head only by applying sprays of water to this portion of the partially-rolled rail at the various passes of the rolls. This, to use his own words, should at any rate improve the wearing surface, and have the advantage of neither delaying the manufacture, decreasing the output nor appreciably increasing the cost. Mr. Sandberg alluded also to the excessive side-wear of the rails on curves on electrified railways, and mentioned that the use of check-rails of a much harder steel had given surprisingly good results.

MR. W. DAWSON described a system of audible signaling on railways which has been put into use by the Great Western Railway Company on a 22-mile length of single line, in

total substitution of the ordinary or visual distant signals, which have been removed. When the atmosphere is clear, either by day or by night, the semaphore signals now in general use fulfil every requirement; in snowy weather, as we have only too good reason to know, the warning arm is apt to become paralyzed; while in the time of fog it is totally invisible, and audible signals have to be extemporized in the form of detonators placed on the rails by a staff of fogmen hurriedly gathered together.

The importance of having a signaling system which is independent of weather conditions needs no emphasis, provided only that it is absolutely to be relied upon. The requirements to be fulfilled may be stated thus:—(1) There must be a distant audible signal of some kind, either "danger" or "all right," at every point where a signal is needed; (2) the signal of "danger" must not be dependent upon delicate electrical apparatus; and (3) any failure or breakage of the apparatus itself should give a "danger" signal.

The system which has received the approval of the Board of Trade, subject to a further examination at the end of six months, may be shortly described thus:—Between the rails a slightly arched piece of timber 40 feet to 60 feet long is secured to the sleepers, and to this is bolted a bar of T iron, suitably mounted and insulated, the bar being electrically connected by means of a length of telegraph wire to a switch at the signal box. The bar is electrified by pulling a lever when it is desired to give the "all right" signal. Any failure of the electrical apparatus has the effect of giving the "danger" signal, and either signal continues—the "danger" by the blowing of a steam whistle, the "all right" by the ringing of a bell, both on the engine—until the driver intentionally shuts it off.

There is no moving part in the ground apparatus, and its action is entirely unaffected by frost or snow. The bell and whistle apparatus is quite simple; it can be readily attached to any type of engine and it operates equally well in whichever direction the engine may be running. There seems to be good reason for believing that this apparatus—which would undoubtedly have averted the Arbroath disaster—will have a further and more extended trial shortly.

Mr. Charles A. Harrison, of the North-Eastern Railway, contributed a note upon reinforced concrete for railway structures, stating that as he personally had not built any bridges in ferro-concrete, he could not speak as to the ability of reinforced concrete to withstand the fatigue and stress of railway traffic. On the other hand, most ferro-concrete structures have proved a success, the exceptions being plainly due to bad material, bad workmanship, or faulty inspection. On the second point—as to the corrosion of the material used for reinforced concrete—he was able to say that so far as the information he had went, unless the bars were very rusty, the oxide of iron on the bars when placed in the concrete produces ferride to a very slight extent round the bars, and practically makes them quite clean.

In the case of ferro-concrete piles in sea-water the bars have been found quite bright and clean, whenever broken up and examined, provided always that the concrete surrounding the bars has been water-tight. Should water get in, however, he was certain, from experience of iron-slag concrete in sea-water, that chemical action would take place and probably render ferro-concrete practically useless.

Mr. Bertram Blount, on the best means of preserving iron and steel work in railway construction, was of opinion that paint, however good the material and however carefully applied, is perishable, and only moder-

ately protective for iron and steel work, and further, is comparatively expensive. The best preservative for iron and steel exposed to the weather is some bituminous preparation. Whether paint or tar be used, the metal should be thoroughly cleaned from scale and rust immediately before the coating is applied; the sand-blast is useful for this purpose. The same need exists where a coating is patched or renewed.

Mr. Blount further stated that for railway structural steel work, such as the frames of buildings or frame foundations, there is no preservative so good as lime or cement concrete, whether the steel framing is bedded in the concrete or forms an integral part of it, as in the various ferro-concrete systems. It is essential that the cement or lime should be of an exceptional quality, and that the concrete should be dense and rich in cement. Steel protected in this way need not first be cleaned from scale and rust.

Mr. William Barrington, on light railway policy, mentioned that the first experiment on a fairly large scale in the United Kingdom was the outcome of the Tramways (Ireland) Act of 1883; and that under this and subsequent acts 600 miles of light railway have been constructed, forming 18 per cent. of the entire railway mileage of Ireland.

During the twenty-four years which have elapsed since the policy was inaugurated, while the total receipts from the main lines of railways have only increased 43 per cent., yet the total receipts of the light railways have shown a steady increase of from 10 per cent. to 119 per cent., even though the population in the districts concerned has decreased from 16 per cent. to 25 per cent. Again, the increase upon those of the light railway systems which are worked independently average 40 per cent more than upon similar lines which are worked by the railway companies. Mr. Blount proceeded to give instances which had come under his notice where the ratio of paying load to total load on a light railway was 27 per cent., while under similar conditions the ratio on a main line of railway was only 15 per cent., and concluded by remarking that "it seems as absurd to expect a country to be economically drained of its traffic by means of standard main lines of railway alone as it would be to attempt to drain its water economically by means of main rivers unassisted by the streams and rivulets, of which Nature has given us examples in abundance."

It is interesting to note that at the Hague conference at the present time, the subject of aerial warfare is treated in almost the same manner as the use of torpedoes and submarine boats was a hundred years ago.

It appears that the principal difficulty in the way of the use of the submarine of Fulton by the French against British vessels was that of obtaining recognition for the operators as belligerents, and the certainty that they would be considered as pirates in case of capture.

To-day the same question arises, except that it is above, in the air, and not beneath the surface of the water, that the alleged piratical conduct is assumed to be effected. If the question were not so serious in its consequences, it might almost be considered as belonging to the absurdities of comic opera. As a matter of fact, the soldier of to-day is dependent upon the engineer for nearly all of his effective weapons, and while workshops and arsenals are busy preparing ordnance and armour plates, and shipyards and foundries are building and equipping the vessels to carry them, it seems grotesquely absurd that aerial warfare should be held barbarous, as were the steamship and the submarine a hundred years ago, and solemnly decreed to await the lapse of another century.

THE terrible disaster at the Quebec bridge can as yet be discussed only in the light of the meagre information now attainable, and it is possible that the destruction of the portions which, by their yielding, caused the wreck may have removed the actual facts from the practicability of any conclusive determination. It is probable, however, that the real stresses upon the structure, or the resistance of the material, or both, were far different from those which were considered to be the case, and hence the subject may be open for consideration in such respect, apart from the details of the failure itself.

The whole history of bridge building has developed a series of changes in the relations of forces and resistances. A plank thrown across a brook has nothing greater to resist than the weight of the person who is crossing; the moving load so far surpasses everything else that nothing more need be considered. When the span becomes greater, the weight of the structure itself becomes important, and in some cases more so than the moving load, especially in masonry bridges. With still greater spans other elements enter to a controlling degree, and hence it is exceedingly difficult to extend experimental data far beyond the limits at which they were determined and be assured that they are reliable.

At the time that Sir Thomas Bouch designed the first Tay bridge, it was considered a masterpiece; yet little or no provision had been made in it for the great wind stresses to which it was actually subjected, and its fall demonstrated that beyond certain points the force of the wind was greater than any other force to which such a structure might be subjected. When the plans for the great Forth bridge were made, this subject of wind stresses was given special attention, and later experience has demonstrated that the magnitude of the strains due to wind had not been underestimated.

In the case of the Quebec bridge, it is too soon, as we have said, to express any definite opinion.

There is one point, however, to which reference may be made, namely, the resistance of long struts to buckling when subjected to thrust. This department of the resistance of structural elements is one concerning which the data available have always to be received with caution. The mathematical analysis is based upon the assumption that the thrust is directly in line with the axis, a condition which it is difficult to attain in the testing machine, and which, we may safely say, is almost impossible of attainment in any actual structure. Even if the conditions are known, it is by no means certain that the results of experiments made upon struts of a given length can be extended safely to those of much greater length, and it must be admitted that it is in just such matters there is a possibility for a wide difference to exist between computed and actual stresses.

As has been well said already in a similar connection:—"A theory takes into account all the conditions which can be ascertained; but an actual structure has to take into account all the conditions there *are*."

JOHN BARRETT

Director of the International Bureau of American Republics

IN view of the recent activity which has been infused into the International Bureau of American Republics at Washington, largely in consequence of the recent visit of Secretary Root to South America and to the third Pan-American Conference at Rio Janeiro, some reference to its work will be of interest, especially in connection with the assumption of the charge of its conduct by the new director, Hon. John Barrett, whose portrait is published as a frontispiece to this issue.

THE NEW BUILDING OF THE BUREAU OF AMERICAN REPUBLICS

The Bureau of American Republics had its origin as long ago as 1890, following upon the first conference of American Republics, held at Washington in that year and presided over by James G. Blaine. This organization is unique in that it is not a bureau, either of the United States Government or of any of the governments of the American republics, but is the independent office of all of them collectively, the fund for its maintenance being provided by appropriations from all, in proportion to their population. Its control is in the hands of a governing board, made up of all the diplomatic representatives of the American republics in Washington, and presided over by the Secretary of State of the United States. The chief administrative officer is the director, chosen by this board, and responsible to it for the management of the bureau.

The new director, Hon. John Barrett, was born in Grafton, Vt., in 1866, and received his education at the Worcester Academy, Worcester, Mass., and at Dartmouth College, from which he was graduated in 1889. He worked his own way through college, paying his expenses by teaching school, and similar means, and after his graduation he went to California, where he became professor of English in the Hopkins Academy, at Oakland. From teaching he entered journalism, becoming assistant editor of the "Statistician," of San Francisco, a connection which brought to his attention the opportunities for the extension of American commerce to the Orient. In 1890 he went to Portland, Ore., as associate editor of the "Evening Telegram," and in 1894 he was sent to Siam as United States Minister, having in charge, among other matters, the settlement of an

THE NEW BUILDING OF THE BUREAU OF AMERICAN REPUBLIC

important claim of an American citizen, Dr. Cheek, against the Siamese Government, involving several million dollars, as well as the interpretation of American treaty rights in all Asia. This matter was settled by arbitration, a large award being secured for the American claimant. About this time Mr. Barrett also was sent on special missions to Japan, Korea, China, and India, to study commercial and general conditions.

During the Spanish-American war in 1898, he resigned his position and went to the Philippines as war correspondent for a syndicate of American and European papers, and in 1899 he made a general tour of Asia as special commissioner of American Chambers of Commerce.

Mr. Barrett returned to the United States in 1901, and was appointed one of the delegates from the United States to attend the second Pan-American Conference in Mexico, while in the following year he made a tour of the world as Commissioner-General of the St. Louis World's Fair, conducting negotiations in connection with the participation of foreign countries.

Mr. Barrett was appointed United States Minister to Argentina in 1903, for the especial purpose of investigating political and commercial conditions, and in 1904 he was made Minister to Panama, his duties involving the adjustment of the new relations between the governments of Panama and of the canal zone. He was then, in 1905, sent as Minister to Colombia, to bring about a restoration of friendly relations between Colombia and the United States, and upon his appointment, in December, 1906, as director of the International Bureau of American Republics, he received notice that the National University of the Republic of Colombia, at Bogota, had conferred upon him the degree of Doctor of Laws and Science, in recognition of his services for the betterment of the relations between North and South America.

It will be seen that Mr. Barrett has thus had exceptional opportunities and experience which render him eminently adapted to direct the work of the Pan-American Bureau successfully and efficiently.

The facilities of the Bureau will be greatly increased upon the completion of the new building, for the construction of which Mr. Andrew Carnegie has generously contributed $750,000, to which sum the republics themselves have added $250,000, making the million dollars required. The illustrations of the buildings are reproduced from the drawings of the architects, Albert Kelsey and Paul P. Cret, of Philadelphia.

Manufacturing News

Voltmeters for Electroplaters

THE importance of a reliable voltmeter in a plating establishment can hardly be exaggerated, as the amount of current consumed in a bath is governed by the quantity of work being done, and the current flow of course is dependent upon the voltage. Too much current (*i. e.,* too high a voltage) results in burned work, while too little current (*i. e.,* too low a voltage) results in a thin deposit, which comes off under the buffing wheel and necessitates replating.

With the aid of a voltmeter all guessing is eliminated and it becomes possible to operate any bath at its maximum efficiency, thus increasing the profit or reputation of the plater.

Owing to the apparently high first cost of furnishing each tank with a reliable and accurate voltmeter, platers have hesitated to properly equip their plants, and have used cheap, unreliable instruments, or have done without instruments of any kind. This is really very poor economy, as even an expensive instrument will soon pay for itself by increasing the quality and quantity of the output.

Realizing the importance of first cost from the plater's standpoint the Weston Electrical Instrument Company has designed a voltmeter specially adapted to this work; which obviates the necessity of having an instrument for each tank and enables the plater to avail himself of an extremely accurate and reliable instrument at a very low cost.

The instrument consists of an accurately calibrated Weston voltmeter,

THE WESTON ELECTROPLATERS' VOLTMETER

contained in an air-tight, waterproof case (which adequately protects the internal mechanism from the action of fumes usually present in the plating room), mounted on a small wooden switchboard containing fifteen binding posts and a fourteen-point switch. One of the binding posts, marked plus, is to be attached to the positive side of the plating

generator or line, while the remainder are to be attached one each to the cathode side of each tank.

After the connections are made the voltmeter is thrown in circuit with any desired tank by turning the switch handle to the numbered point corresponding to the tank it is desired to test.

The instrument is designed to accommodate fourteen tanks, which is considered the maximum that can be conveniently operated from one point. Any lesser number of tanks may be connected in circuit, however, as each binding post is entirely independent.

The Lazier Gas Engine

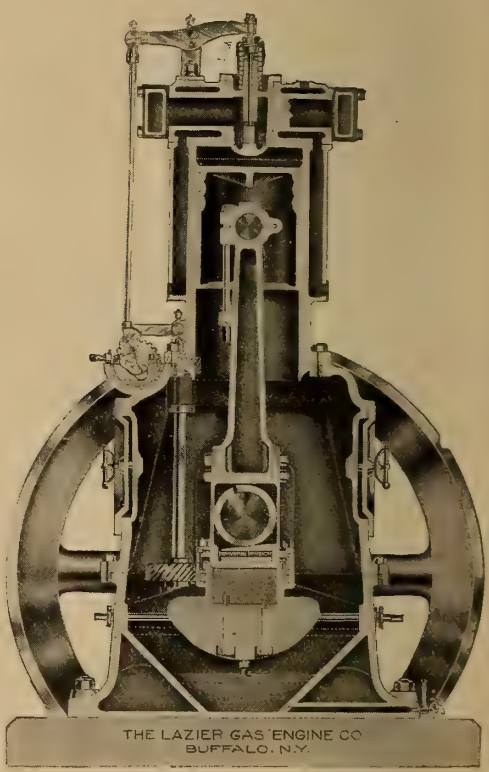
WE give herewith front view and cross section of the new Lazier Gas Engine, recently perfected by Mr. Arthur A. Lazier, and just placed upon the market. Mr. Lazier announces that he has disposed of his entire interest in the Lazier Engine Manufacturing Company, of Buffalo, and has organized the Lazier Gas Engine Company, with headquarters in Buffalo, N. Y., for developing the new engine and pushing it upon the market.

The engine is of the vertical multiple-cylinder type, operating on the four-cycle principle, with throttling regulation, and is built in sizes from 50 to 300 horse power, being designed for general power and lighting duty. The general construction is well shown in the illustrations, and is supplemented by the following description:

The base, upper base, cylinders and heads are cast separate. There is no mechanism on the inside of the engine, except the piston, crank and connecting rod.

The cam shaft runs in oil and is visible at all times. Every part of the machine is get-at-able in a moment. The main bearings are provided with wedge take ups and pin gauges to determine the alignment. The connecting rod bearings are quickly gotten at for adjustment by removing the hand plates on either side of the base. Crank shafts are extremely large and are counter-balanced.

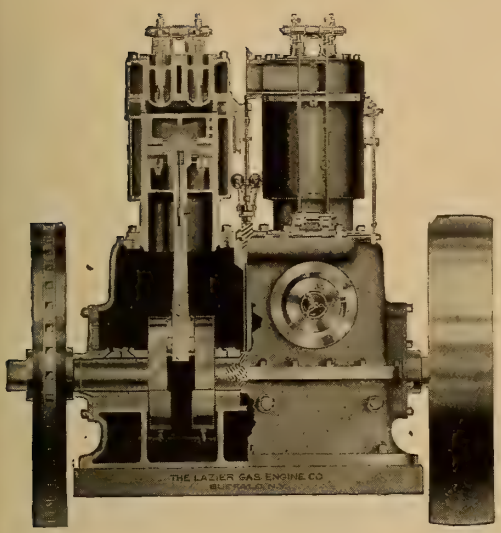
One of the most necessary and important features in a gas engine is the ignition. Constant and uniform firing of each mixture of fuel drawn into the cylinders depends on the perfect working of the igniter. To eliminate and guard against these



THE LAZIER GAS ENGINE, CROSS SECTION

troubles, the Lazier gas engine is equipped with both the make-and-break and jump-spark types, so that change from one to the other can be made instantly without loss of time. They are adjustable while engine is operating, and when desired can be used together.

In order to get the best economy, all ports in the explosion chamber have been eliminated, the mixture being admitted directly into the cylin-



THE LAZIER GAS ENGINE

der proper. The valves are interchangeable, mounted on cages and are removable in a moment.

All engines are arranged to change from natural to producer gas without any material change in the engine or its mechanism. The throttle or mixing valve is balanced and so designed that it is impossible to clog up.

Lubrication is taken care of automatically, no oil being thrown out of the crank case or into the engine room.

The system of water cooling keeps the cylinders cooler on top, where the heat is most intense, than at the bottom, which prevents uneven expansion and produces the best fuel economy.

The drive for operating the cam shaft and governor is entirely new, simple and effective, consisting of but four spiral gears, which make the engine practically noiseless and a system that will not wear out, as all gears run in oil.

Rock Crushers in Building Reconstruction

IN the re-building of San Francisco, methods of economical leveling and construction have been sought out and practiced to a greater degree, probably, than at any other time and place in the world's history. As an instance typical of this, we may cite the work done on the Crocker Building, standing at the corner of Post and Market Streets, where every avenue to waste, both of material and labor, has been most successfully closed through the exercise of a little ingenuity and forethought, aided by the best of modern crushing machinery.

This structure, which is ten stories in height, with a frontage of about 200 feet, escaped any serious damage from the earthquake, but was gutted by fire.

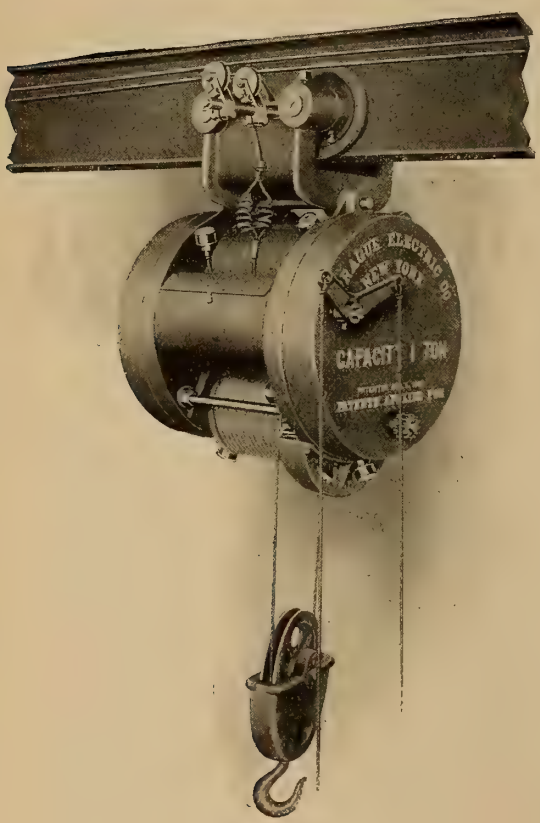
The frame of the building being intact, nothing more was necessary than a reconstruction of its interior, and the contractors at once hit upon the profitable plan of utilizing for concrete mixture all bricks, tiling, stone work and flooring which had to be removed. Suitable apparatus was therefore installed, and, as fast as the work of tearing down made this material available, it went directly to an Allis-Chalmers "Gates" breaker, fed from bins supplied by chutes from various sections of the building. After being crushed to the desired fineness, the product of the breaker passed to a mixer, and as the concrete material issued from the latter, it was taken by a system of elevators and conveyors to all parts of the building where needed.

The significant feature of this process lies in the fact that, from the moment the material was taken from the walls and floors until the time it again became a part of the structure, there was not the slightest break or loss in its handling. Economy could scarcely be carried farther.

Of chief importance in this outfit is the breaker installed by Allis-Chalmers Company for the Roebling Construction Company, who state that they are very much pleased with the results obtained from it.

Sprague Electric Hoists

IN the present condition of nearly all manufacturing industries it has become imperatively necessary to provide, as much as possible, mechanical appliances for performing work formerly accomplished by human effort. Heavy handling is done by cranes of various kinds and by special arrangements of track and cars, but for lighter work the overhead tram rail and light hoist has come into general use. For some work hand hoists are entirely ade-



SPRAGUE ELECTRIC HOIST

quate, but light power hoists have found a continually widening field of service.

The above illustration shows one of the various forms of electric hoist made by the Sprague Electric Company, attached to a plain carriage for running on the lower flange of an I-beam. This hoist is made in capacities of one ton and half ton, and is furnished without carriage or complete with plain, hand-geared, or motor-driven carriage, the latter form being that shown in the illustration.

Quite apart from first cost and operating expense, the small electric hoist and carrier system has advantages peculiarly its own. A properly designed installation is not only capable of handling as many packages as there are hoists installed, but is also capable of being extended to provide for an increase of product to be moved without material increase in the runway system, and without discarding any part of the original equipment, and most important of all, the hoists and carriers can pass each other, conveying their respective packages to their proper destinations, without the delay which would be caused by a piece of apparatus which monopolized the entire runway when in use.

An air hoist is tied to its base of supply, the pipe line, by a length of rubber hose, and its radius of action is limited. It is practically impossible to arrange an extensive overhead trackage system which will permit one air hoist to pass another. Chain blocks are much too slow, except for occasional use, and air hoists and chain blocks are not usually equipped with a power motor to propel them along the runway. Their carrying capacity, per hour or day, is accordingly very much less than that of the electrically propelled hoist.

The use of more than one electric traveling crane on a runway blocks the runway, as it is not possible for the cranes to pass each other.

This company has installed many electric carrier and hoisting systems. One order called for a mile and a half of overhead track, one hundred and fifty switches, and hoists and carriers in proportion.

News Notes

On May 1 the Chicago branch of Niles-Bement-Pond Company, largest manufacturers of machine tools in the world, will occupy their new offices on the sixth floor of the new Commercial National Bank Building, Clark and Adams Streets, Chicago. In this building will also be located many of the large engineering and steel companies.

Pratt & Whitney Company will abandon their show room and offices at No. 46-48 South Canal Street, and will combine their machinery sales department with that of Niles-Bement-Pond Company.

The show room and stock of Pratt & Whitney Small Tools, and the Small Tools Sales Department, will be located on the ground floor of the new Plamondon Building, Clinton and Monroe Streets, where a complete line of Pratt & Whitney small tools and gauges will be carried in stock.

Mr. George F. Mills, who has for several years looked after the interests of these companies in the Chicago territory, will continue as manager of the Chicago offices.

A change of company name of more than usual interest to the trade took place April 1, 1907. On and after that date the Sawyer-Man Electric Company will be known as the Westinghouse Lamp Company. Thus the name of the pioneer company in the lighting industry becomes a matter of history. It has of course been generally understood for some years past that the Sawyer-Man Electric Company was a Westinghouse interest, and the change of name is but a logical result of changed conditions.

On May 1, the Clinton Wire Cloth Company, Clinton, Mass., will remove its New York office from 33 Park Place to 261 Broadway. At the same time, the Chicago office will be removed from 237 Lake Street to 30 and 32 River Street. For over half a century this concern has been manufacturing wire cloth of every description, embracing woven wire fence, electrically welded wire fabrics for concrete construction, wire lath, hexagonal netting, perforated metals, etc., during which period these products have been the standard in their line.

Additional indication that the business centers of San Francisco will be located in the same districts as they were before the fire is offered by the decision of the Mutual Life Insurance Company to repair and occupy their building at the corner of Sansome and California Streets. The lower stories will be occupied by the Canadian Bank of Commerce and the upper stories will be occupied by the Mutual Life Insurance Company. The architect for the alterations and repairs is Mr. Nathaniel Blaisdell. The contract for this work was recently awarded to the Frank Gilbreth Company on the cost-plus-a-fixed-sum basis.

The Crocker-Wheeler Company, whose main office and works are at Ampere, N. J., has found it impossible to handle its rapidly increasing business in electric motors and generators in Birmingham, Ala., from its New Orleans and Baltimore offices, and has been obliged to establish headquarters in Birmingham. The company's celebrated rolling mill motors, the only line of motors ever built especially for this arduous service, is the C-W specialty, which has made the greatest impression in Birmingham. The new office, which is in the Woodward Building, Birmingham, is in charge of Mr. B. A. Schroder, who hitherto has taken care of the New Orleans territory of the company.

THE LATEST CATALOGUES

Dredging

RISDON IRON WORKS, San Francisco.—Catalogue No. 17, Sixth Edition, devoted to a discussion and description of the Risdon Gold Dredging Machinery as applied practically in California, Alaska, Africa, and the Philippines. The whole subject of gold dredging is examined practically, and numerous handsome illustrations show the manner in which the Risdon dredges have been applied in important fields in various parts of the world. Detailed reports of the operations of dredges are given, together with an analysis of the cost of repairs and the proportion of actual working time which may be obtained from these machines.

Pumps

R. D. WOOD & COMPANY, Philadelphia.—Catalogue of centrifugal pumps, as designed for water works and high-pressure fire service. A pactical description of the applications of multiple centrifugal pumps, with numerous examples showing the manner in which these machines may be applied to advantage in locations where large volumes of water are to be handled at moderate or high pressures. The adaptation of the centrifugal pump to steam, gas, or electric power is discussed, and the illustrations show the action of installations in connection with high-pressure fire sevice, as well as regular operative conditions in manufacturing establishments.

Heaters

HOPPES MANUFACTURING COMPANY, Springfield, Ohio.—Catalogue descriptive of the Hoppes live-steam feed water purifiers and exhaust steam feed-water heaters, with numerous illustrations showing the effectiveness of these appliances in removing scale forming materials from feed water before it enters the boiler. Steam separators, oil eliminators, and exhaust heads are also shown.

Conveyors

JEFFREY MANUFACTURING COMPANY, Columbus, Ohio.—Special supplementary catalogue of Jeffrey conveying machinery for saw mills, lumber mills, and woodworking industries. This catalogue is filled with illustrations showing the design and application of conveyors for hauling the logs to the mill and for removing the sawdust and refuse. The data include chain, wire rope, and belt carriers, and show the appliances in actual service in numerous practical installations.

Sheet Metal Machinery

W. H. HIBBARD MANUFACTURING COMPANY, New York.—Catalogue of presses, dies, and shears, combined punches and shears, and special machinery for working sheet metal by press work, spinning and drawing. A great variety of presses, shears, spinning lathes and drawing machines are illustrated, with valuable data and information for manufacturers in these departments of work.

Boats

TRUSCOTT BOAT AND AUTO SUPPLY COMPANY, St. Joseph, Mich.—Catalogue No. 2, of supplies and accessories for motor boats, automobiles and motorcycles. A large detailed descriptive catalogue of all kinds of supplies relating to motor vehicles and boats, including tires, lamps, chains, batteries, electrical appliances, clothing and tools.

Steam Fittings

MCNAB & HARLIN MANUFACTURING COMPANY, New York.—Well bound catalogue of brass and iron goods for steam, water, and gas, including pipe, valves, and fittings. This is the ninth edition of the general catalogue of this well-known manufacturing house,

and includes detailed descriptions and data of all the elements which go to make up the necessaries for the steam and gas fitter.

Tool Grinders

GISHOLT MACHINE COMPANY, Madison, Wis.—A well printed and illustrated catalogue discussing the correct system for grinding tools in the machine shop, wherein the tools are ground to predetermined angles and shapes according to a standardized system, by special employees. The use of numbered charts is shown, as well as the employment of former blocks at the forge, and the whole subject of correct and systematic preparation of tools for their work, independently of the workmen at the machines, is clearly set forth. In this connection the applicability of the Gisholt tool grinder to this system is emphasized.

Rock Drills

INGERSOLL-RAND COMPANY, New York.—Booklet describing the Temple-Ingersoll Electric Air Drill. This is a simple form of rock drill, combined with an air compressor and electric motor, so arranged that the whole forms a compact and self-contained drilling outfit, adapted for use where electric energy is available. All the advantages of the air drill are retained, together with the use of electricity as a means of transmitting the power to the heading or other point of application.

Iron Cements

SMOOTH-ON MANUFACTURING COMPANY, Jersey City, N. J.—Edition No. 5 of the Smooth-On Instruction Book, describing the application of cements for repairing defects and blemishes in castings, for making joints, and for repairing leaks and connections in steam and hydraulic work. Illustrations of many successful applications are given, and numerous testimonials from engineers, contractors and manufacturers.

Gas Engines

BRUCE-MERIAM-ABBOTT COMPANY, Cleveland, Ohio.—Circular describing improved four-cycle, multiple-cylinder gas engines, adapted for natural, artificial, or producer gas, or for gasoline, in sizes from 12 to 200 horse-power. The applicability of gas engines to electric lighting plants is emphasized, and testimonials from important customers are given.

Generating Sets

B. F. STURTEVANT COMPANY, Hyde Park, Mass.—Bulletin No. 143, illustrating and describing direct-connected generating sets, consisting of horizontal engines and eight-pole electric generators, adapted for isolated plants from 20 to 150 kilowatts. Details of the engine and dynamo are given, and tables of general dimensions.

Locomotives

AMERICAN LOCOMOTIVE COMPANY, Schenectady, N. Y.—Two pamphlets, one devoted to engines of the Mogul, or 2-6-0-type, as applied to freight service on various railroads, and the other describing the Ten-wheel, or 4-6-0, type of engines, in sizes weighing more than 150,000 pounds. These catalogues are fully illustrated from photographs of actual engines built and delivered, with tables of principal dimensions and capacities, forming valuable reference books of these important types.

BALDWIN LOCOMOTIVE WORKS, Philadelphia.—Record No. 60, being a paper read before the Pacific Coast Railway Club by William Penn Evans, comparing the actual efficiency of a modern locomotive, as represented by the work performed, as compared with the lighter locomotive of twenty years ago. A convenient reprint of a valuable study of locomotive performances showing the gains due to superheating and compounding, and to the general improvements in construction during a period of twenty years.

Limits to Losses in Compressed Air Service

WE hear certainly enough, and probably too much, of the power losses which inevitably accompany the employment of compressed air as a transmitting and operating medium. We certainly do not hear enough of, and do not sufficiently bear in mind, the fact that whatever these losses may be there is always a limit to them which cannot well be exceeded. Steam losses seem to be without limit.

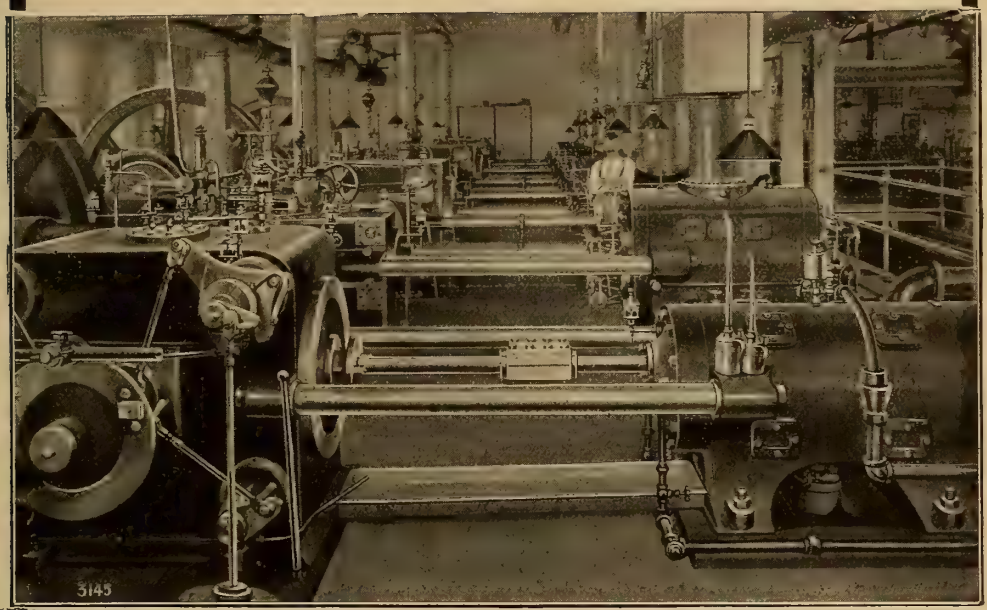
In the development of power by means of steam the coal-cost per horse-power hour in steam-operated apparatus in actual use ranges from below two pounds to above forty pounds. There is no loss in compressed air practice comparable with this. In the compression of air to, say, six atmospheres, a very common working pressure, the power cost by adiabatic—the most costly—compression exceeds the cost by the ideal and practically impossible isothermal compression by only 32 per cent., and there is no discoverable way of making the cost of air compression any greater. The air compressors in use a score of years ago were crude and wasteful as compared with those which may be considered standard today. In the improvements which have been made in steam-driven air compressors the power savings effected have been much greater at the steam ends than at the air ends.

But it is rather in the employment of the air after compression that the limitation of losses most asserts itself. The unceasing condensation and disappearance of steam, beginning immediately upon leaving the boiler and continuing uninterruptedly after leaving belongs to steam alone; air has no corresponding or comparable loss. The volume of air delivered by the compressor decreases somewhat with its fall of temperature, but when normal temperature is reached shrinkage ceases and this loss ends. The water of condensation is another thing to be reckoned with in the use of steam, and also the delay and the steam-cost of heating up the steam-operated machine every time it is operated, with neither of which conditions does the air have anything to do. Compressed air seems to be unique among power transmitters in that it is always ready to do its full work and yet charges nothing for its time while standing waiting.

The beginning of the employment of compressed air for driving rock drills in mines and tunnels was enforced by other considerations than these, but mines and tunnels are not now the largest employers of compressed air. It is no wonder that we find it making its way for work in the open, that many quarries are operated by it exclusively, that such undertakings as the enormous excavations in New York for the new stations of the Pennsylvania and the New York Central Railroads should each depend upon the air compressor to do the most of the work. Most of the air in these cases is not transmitted more than the length of half a dozen city blocks; where the distances are greater the advantages of air power transmission becomes more pronounced, and so it is entirely in line with the most advanced engineering practive that air compressors are finding employment upon the Panama Canal. When we hear of many more compressors being installed upon the job we may find therein increased encouragement to hope for the ultimate successful completion of the work.

Notwithstanding the many great engineering works in progress and the number of air compressors employed upon them, there seems to be little danger of their working themselves out of a job. Their work grows upon them and one thing follows another. Two of the largest of the 100 compressors now employed upon railroad and tunnel work in or immediately in touch with New York City were previously used on the excavation work for the Jerome Park reservoir of the New York Waterworks, another in open-air operation.

CORLISS AIR AND GAS COMPRESSORS



Three of the four Ingersoll-Rand Corliss Air Compressors in the Weehawken Plant of the O'Rourke Engineering Construction Co. used in driving the North River Tunnels of the Pennsylvania Railroad entering New York. A duplicate is installed at the New York End of the tubes.

Ingersoll-Rand Corliss Compressors combine the exclusive superiorities of former Ingersoll-Sergeant and Rand types, more of which are in use to-day than of all other makes combined. THE INGERSOLL-RAND COMPANY GUARANTEES ITS CORLISS AIR AND GAS COMPRESSORS TO DELIVER COMPRESSED AIR OR GAS WITH A LOWER STEAM CONSUMPTION PER CUBIC FOOT, AND TO MAINTAIN A HIGHER ECONOMY OVER LONGER PERIODS OF ACTUAL OPERATION THAN ANY OTHER CORLISS COMPRESSOR MADE.

ROCK DRILLS AIR TOOLS CALYX CORE DRILLS

INGERSOLL-RAND CO.

CHICAGO PHILADELPHIA 11 BROADWAY ST. LOUIS EL PASO
CLEVELAND HOUGHTON NEW YORK PITTSBURG BOSTON
SEATTLE SAN FRANCISCO BUTTE SALT LAKE BIRMINGHAM DENVER
MONTREAL JOHANNESBURG LONDON BERLIN MELBOURNE PARIS

V22

Fuel Economy

IN considering the attainment of maximum economy in the extraction of mechanical energy from fuel there are a number of elements to be taken into account if the total efficiency of the plant is to be determined. Too often only a portion of the actual conditions are considered in making computations or scientific studies, but in actual practice the plant in operation will itself be governed by all the conditions there are.

Thus, it is entirely possible to measure the quantity of heat energy in the particular kind of fuel consumed, as well as the quantity delivered in the steam, and the relation between these enables the efficiency of the boiler to be computed. This, however, is only an intermediate portion of the conversion of the money expended in running the plant into power of a definite money value. In many cases the cost of the fuel is but a moderate proportion of the total cost of the power and in general it has been stated that the fuel cost will average about one-half of the entire power cost, for an ordinary plant. This means that all the other elements of the cost of power in a station are together as important as regards the total efficiency as is the fuel bill.

Naturally one of the most important of the elements other than the fuel is the item of labor. Before the coal can be burned it must be brought from the car, the yard, or whatever point of delivery marks its arrival, carried either to the heap or to the storage bin, conveyed to the boiler room, and fed to the grates. Even after it is burned, and its combustible portion has passed through the flues, delivered up its heat to the boiler and escaped through the chimney, there remains the ash to be removed and delivered to the dump, and both of these items, the delivery of the coal and the removal of the ash, form important elements in power cost. This is especially the case when the costly and inefficient methods of manual labor are employed. Modern power-house design includes, therefore, as one of its essential elements, the provision for the installation of well-designed and strongly constituted coal-handling machinery.

The question of hand firing *versus* automatic stokers bears upon the subject of coal handling in a secondary manner. That is, either method of firing requires the coal to be delivered to the point where the furnace is to be fed. In the case of hand firing the old method of keeping a heap of coal in front of the boiler is objectionable, and with large installations it is most undesirable. In such plants the modern method provides a line of industrial railway running before the furnaces, and equipped with charging cars provided with either double or single doors, according as to whether the boilers are on one or both sides of the track. If overhead coal-storage bins are provided, it is only necessary to have the pipe chutes brought down at convenient points and fitted at the bottom with duplex cut-off valves to enable the cars to be filled and the coal delivered to the boilers as required, no more coal being drawn from the bins than is needed for immediate use.

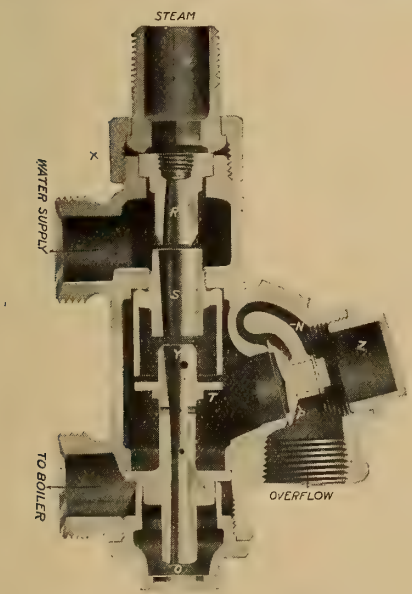
If automatic stokers are installed there are several methods by which the coal may be delivered to the feeding hoppers. Flexible chutes may connect with the overhead storage bins, or an electric locomotive may carry a larry and deliver the coal directly to the furnaces, this latter method being especially applicable when the coal has to be brought from some adjoining place. Where the careful record of fuel is kept, which should form a portion of any systematic steam plant, the coal passes through a movable weighing hopper, so that the determination of the quantity consumed becomes a portion of the regular routine of the boiler house.

Manufacturing News

The Penberthy Automatic Injector

AN injector so well known and widely used as the "Penberthy" needs hardly a word of introduction.

The "Penberthy" automatic injector is a perfect restarting automatic machine. By this is meant that when



SECTIONAL VIEW OF THE PENBERTHY AUTOMATIC INJECTOR.

the injector is working, if the current of water be suddenly interrupted as is liable to happen from a sudden jar or jolt (on such apparatus as traction engines or road rollers, or in the case of a marine boiler by the rolling of the vessel) this injector will automatically re-establish the current without attention from the attendant.

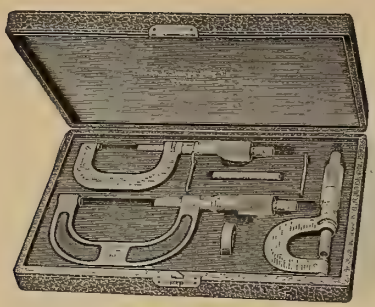
This is one of the features that has given the "Penberthy" such a hold among marine engineers and traction and threshing engine manufacturers of the United States.

The "Penberthy" is so constructed as to have but few wearing parts and will last for years with proper care without renewals. All parts are interchangeable, however, when required.

The Penberthy Injector Company, of Detroit, Mich., are among the pioneers and the largest manufacturers of automatic injectors in the world. Their steadily increasing business necessitating frequent enlargements of their already immense plan, is a fitting testimonial to the merits of their output.

Micrometer Calipers

THE extent to which instruments for precise measurements are now used in the workshop is indicated by the manner in which such appliances are made and offered for shop use. Instruments which, a few years ago, formed only a portion of the tool-room equipment are now available for the machinist and workman



BROWN & SHARPE MICROMETER CALIPER SET.

and form portions of the kit of the skilled mechanic in nearly every large shop.

The illustration shows a micrometer caliper set made by the Brown & Sharpe Manufacturing Company, Providence, R. I., forming a complete outfit ranging from zero to 3 inches in capacity, or from zero to 75 millimetres in the metric system.

This set of micrometer calipers forms an inexpensive set of accurate and convenient reference tools for inspecting the finished product as well as for general shop use.

The 1-inch and 2-inch calipers are the standard type, with decimal equivalents stamped on the frame and provided with the clamp ring. The 3-inch caliper has a frame of I section which combines the greatest lightness and rigidity.

Each micrometer is graduated to read to thousandths of an inch. The set is neatly arranged in a substantial case lined with velvet and covered with leather. These instruments are made with ratchet stop, when so ordered.

A standard reference disk is furnished for adjusting the 2-inch caliper and a standard end-measuring rod for the 3-inch.

Electric Motor Drive For an Alaskan Gold Dredge

THE Bonanza Basin Gold Dredging Company, which has been operating during the past years in the Bonanza Basin district of Alaska, with steam driven gold dredges of Allis-Chalmers and other designs, recently made arrangements for obtaining a supply of electric current from the Dawson Electric Light and Power Company, of Dawson City.

In order to take advantage of the electric power which is now available, the dredging company has ordered the alteration of the big Allis-Chalmers dredge, which is the "Sluice Type," steam driven, to the "Stacker Type," electrically driven.

This alteration necessitated the use of separate motors for each specific drive throughout the dredge, in addition to the substitution of new winches and gravel handling devices required by the change from sluice to stacker type. The current to be used will be alternating, 3-phase, 60-cycle, 2300 volts.

The motor equipment will be made up of Allis-Chalmers standard induction motors as follows:

The bucket drive motor will be 100 H. P., 2300 volts, under variable speed and reversing. A 50 H. P. constant speed, 2300 volt motor will drive 12-in. pump. Two variable speed 30 H. P., 440 volt machines will drive the main and ladder winches. A 15 H. P. constant speed, 440 volt motor, operating at a speed of 1130 R. P. H., will operate the screen and stacker hoist. The stacker will be driven by means of a constant speed motor, 15 H. P., 440 volt. A 3-in. primer pump will be driven from a 10 H. P. constant speed machine.

The stacker for this dredge will have 80 feet centers and a belt 30 feet wide, driven from the top end by a motor.

This dredge has already established for itself a rather unique record. One of the strangest "clean-ups" in the history of mining is reported to have been made from it, after a part of its run last summer in the sloughs of the Bonanza Basin.

When the sluice box was opened preparatory to the periodical clean-up, after quite an extended period of

operation, it was found that the bed of the slough, which had just been worked, had yielded an assortment of stuff, the equal of which, according to the papers at Dawson City, had never been seen before in the mining regions of the west. The collection disclosed among other things two Russian bronze ikons, or sacred figures, which had probably been carried into the region by Russian explorers many years before the Klondyke was heard of. These ikons were identical with those carried by some of the regiments of the Czar's armies in the late Japanese war. In addition to the ikons were found eight American pennies, probably thrown into the slough by some prospector in a fit of disgust, when he realized that they possessed no purchasing power in the Yukon district. There were also recovered about 100 pounds of unexploded cartridges; gallons of bullets, many of which had a coating of amalgam, which necessitated their treatment for the gold adhering; 120 pounds of nails of all sizes; an alarm clock; a saw set; two massive gold charms; an opal with its setting from a broken scarf pin; innumerable pieces of watch chains; knives, forks, keys, locks, native bismuth, etc.

During the season many large clean-ups were made, the gold was coarse and nuggets worth from $10 to $20 apiece were recovered.

A Variable-Speed Continous Transit System

IT is now becoming recognized that one of the main causes of the congestion of municipal transport systems lies in the intermittent character of the service. The people accumulate while waiting for the car or the train, and then the time required to discharge passengers and take on the waiting crowd becomes the limit to the headway between trains or cars.

It was for this reason that the so-called traveling sidewalk was designed, and experience in Paris during the exposition of 1900, and elsewhere, demonstrated that such a device has an enormous carrying capacity, even when operated at a moderate rate of speed. The traveling sidewalk, however, involves the use of a system of slower platforms at the stations, these giving a series of successively increasing speeds, so that the passengers can step safely from one to the next until the speed of the main platform is reached.

A new plan is the Adkins-Lewis system, this involving a variable speed for cars, with a rapid movement between stations, slowing down, without stopping, at the stations to permit passengers to alight and mount.

This plan necessarily demands a special method of driving, and in this respect the Adkins-Lewis system differs from the traveling sidewalk, which moves with a uniform velocity. The driving portion of the new scheme includes the use of a pair of screws or rather shafts, in each of which a spiral groove is cut. One of these is formed with a right-hand spiral and the other with a left-hand spiral. These opposed spiral grooves receive the opposite ends of the forward axle of each car, so that when the shafts are turned in opposite directions they feed or "screw" the cars forward. The desired acceleration or retardation of the cars is produced by varying the pitch.

In this system a series of short cars are used, which travel at high speed between stations, but slow up while passing a station platform to permit the passengers to alight or step aboard. In this respect the system resembles that of separate trains. However, the cars do not stop at the station, but come together at a rate of three miles per hour.

Apart from the mechanical details of this ingenious plan, these latter necessarily demanding the test of severe practical service, the fundamental idea of the system is extremely ingenious, and is applicable to vertical or inclined elevators as well as to horizontal transport.

A Dead Weight Gauge Tester

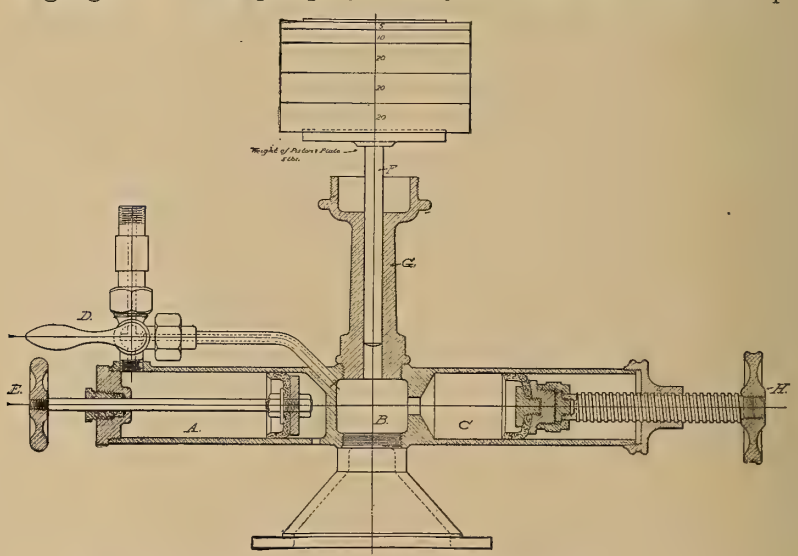
THE dead weight gauge testing machine shown in the annexed cut is made by the American Steam Gauge & Valve Manufacturing Company, of Boston, and is claimed to be a decided improvement over anything now on the market for the purpose. It possesses all the advantages of the mercury column enclosed in a much smaller space, and supplies a want for a testing apparatus which can be relied upon to be absolutely accurate at all times.

It does away with the necessity of returning test gauges to the factory for readjustment from time to time, in order to be assured of their accuracy.

The cut tells its own story. There is an auxiliary cylinder *A* connected with the gauge and main pump cylinders *B* and *C* through a three-way cock *D*, the connection being made by turning the lever cock connected with either gauge to main pump cylinders, as is desired, eliminating the necessity of pouring the oil in and out of the pump cylinders before and after testing.

The auxiliary oil chamber *A* and main pump cylinders *B* and *C* are filled with a light mineral oil, the cylinder *A* being filled through the pump cylinder *G* by removing the plunger *F*, turning the three-way cock so as to connect cylinders *A* and *B* through the connecting tube. Before the oil is poured in, withdraw plunger *E*, and as the oil is poured in, push in on the plunger *E*, drawing oil over through tube and cock, thus filling the cylinder *A*.

The main pump cylinders *B* and *C* are filled through the pump cylinder *G* by screwing out on screw plunger *H* as the oil is poured in. In testing, it is not necessary to continually screw in on the pump plunger *H*. After the table and piston *F* have been lowered by the first application of weights and have been raised by the screw plunger, it is only necessary to raise the table and plunger twice while testing to 500 pounds. Another feature is the fact that after completing the test of a gauge, the cock may be turned connecting gauge with cylinder *A*, and by pushing in on plunger *F* the connections and gauge tube can be drained of the oil, thus preventing spilling when the gauge is disconnected.



A DEAD WEIGHT GAUGE TESTER, MADE BY THE AMERICAN STEAM GAUGE & VALVE MANUFACTURING COMPANY, BOSTON.

The gauge to be tested is attached

to the nipple connected by the union above the three-way cock *D*. The gauge and fittings are then filled by withdrawing piston *E;* then turn the three-way cock in the position which places the gauge in communication with chamber *A*. When the movement of the index hand indicates what pressure is on the gauge, the three-way cock is turned so as to put the gauge in communication with chamber *B*. The weights are then applied to the desired pressure, being revolved from time to time to obviate friction.

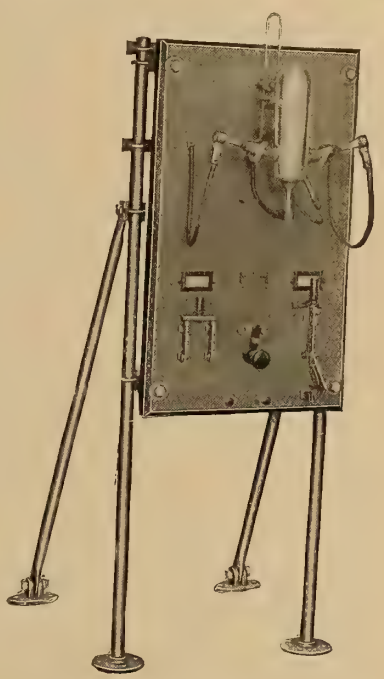
After the weights are first applied, the table should be raised to a position of 2½ inches above cylinder *G* to prevent the table from striking. The table is raised by screwing in plunger *H*.

Mercury Arc Rectifier Panel for Charging Ignition Batteries

THE mercury arc rectifier, as a substitute for the motor-generator set for charging vehicles, has already become familiar to the owners of electric automobiles. A smaller size of this form of apparatus for changing the alternating current of the ordinary city lighting circuits to direct current for charging ignition batteries, will be of particular interest to owners of gasoline machines.

Storage cells are admittedly superior to any form of primary battery, either wet or dry for ignition work, but are not as widely used as they could be owing to the inconvenient and expensive methods of charging. For storage batteries a direct current is required and on city lighting circuits this is not generally available, alternating current being used almost universally for electric lighting.

The mercury arc rectifier, developed by the General Electric Company to meet these conditions, consists of a mercury arc rectifier tube having a sufficient capacity to charge five cells of the ordinary ignition type. This tube is mounted compactly with switches and rheostat upon a slate panel sixteen inches wide and twenty-eight inches high. Referring to the illustration, in the lower right right-hand corner of the panel can be seen the starting switch, at the opposite side the load switch, while between the two is a small rheostat arranged in series with the load so as to adjust the voltage between the limits necessary for charging from two to five cells of battery.



MERCURY ARC RECTIFIER.

Such a mercury arc rectifier outfit will charge a five-cell ignition battery in eight hours. At ordinary rates for electric current this means an expenditure of about 25 cents a week for keeping the batteries in first-class order. The outfit comes all set up on the panel with the exception of the tube which can easily be hung in its supporting frame and connected.

The rectifier method of charging is well adapted for private as well as public garages because of its convenience, simplicity and economy.

THE LATEST CATALOGUES

Crucibles.

THE JOSEPH DIXON CRUCIBLE COMPANY, Jersey City, N. J.—A treatise on crucibles; their care and use. This pamphlet, while issued as a proprietary publication, forms a valuable general treatise upon the manufacture and proper use of graphite crucibles, and as such should be given place in the technical library as a very useful work of reference. This book is the work of Mr. John A. Walker, for many years the general manager of the Joseph Dixon Crucible Company, and one of its officers, and its contents give the reader the benefit of a wide practical experience in an important department of industry.

Condensers.

THE DEANE STEAM PUMP COMPANY, Holyoke, Mass.—Descriptive circular of jet condensers, air pumps, and auxiliary apparatus for the production and maintenance of a high vacuum for steam turbines. Both wet and dry air pumps are shown, together with information concerning the importance of a high vacuum for the most efficient operation of steam turbines, and the necessity for reliability and safety in the apparatus.

Water Softening.

C. A. FELBER, New York.—Pamphlet describing the Breda system for the softening and purification of water for industrial and steam making purposes, illustrating the apparatus as manufactured by John Turl's Sons, Newburgh, N. Y. The catalogue contains a number of testimonials from users of the apparatus, and illustrations of installed plants.

Drills.

KEYSTONE DRILLER COMPANY, Beaver Falls, Pa.—A descriptive article by F. S. Pheby, reprinted from the "Mining and Scientific Press," giving an account of the use of churn drills for prospecting for copper at Ely, Nevada. Data concerning the speed and cost of drilling are given.

Gas Power.

BACKUS WATER MOTOR COMPANY, Newark, N. J.—Catalogue of Backus suction gas producers and gas engines as applied to independent plants of moderate size. Detailed illustrations of the producer are given, and tables showing the comparative cost of power as generated by steam, gasoline, and gas engines of the ordinary and the suction producer types. Dimensions and weights of suction producers and of gas engines are appended, with testimonials of various users showing the economy and reliability of the system.

Presses

FERRACUTE MACHINE COMPANY, Bridgeton, N. J.—Temporary Catalogue 15, describing foot and power presses for working bar and sheet metals, paper, cloth and leather. This catalogue contains a large number of minature illustrations enabling the scope of the products of the establishment to be seen, together with more extensive illustrations and tabulated specifications of some of the more recent designs of presses. Among these may be mentioned an improved armature notching press, especially adapted for notching external and internal disks for electrical machinery, double-acting drawing presses, coining presses, etc.

Sprocket Wheels.

LINK-BELT COMPANY, Chicago, Philadelphia, Indianapolis. Revised price list of sprocket wheels for Ewart link-belts, for pin chains, and for rolling chains. Ewart traction wheels for elevators are also listed, as well as chilled charcoal-iron sprocket wheels for Ley steel-bushed chains.

Transformers.

PITTSBURGH TRANSFORMER COMPANY, Pittsburgh, Pa.—Fully illustrated catalogue of electrical transformers for lighting and power service in sizes from 6-10 kilowatt to 50 killowatts, and for pressures up to 50,000 volts. Details of construction and design are given, together with instructions as to use and care, also form of proposal under which the manufacturers arrange for the entire supply of a customer under a yearly agreement.

Air Compressors.

SULLIVAN MACHINERY COMPANY, Chicago.—Catalogue No. 58, devoted to modern practice in air compression as exemplified in the Sullivan air compressors and allied machinery. The general con struction of the compressors is well shown from photographs and by detailed drawings, together with much useful information about the production and applications of compressed air.

Mining Machinery.

COLORADO IRON WORKS COMPANY, Denver, Col.—Catalogue No. 7E, describing concentration mills and machinery, together with useful information regarding the treatment of ores by concentration. Various types of breakers and crushing rolls are illustrated, also screens, conveyors, grinder, concentrators, etc., together with plans and specifications for a first-class concentrating mill.

Electric Fans.

B. F. STURTEVANT COMPANY, Hyde Park, Mass.—Bulletin 146, illustrating and describing disk propellor fans, operated by electric motors, for moving large volumes of air against low resistances. The conditions of operation of such machines to advantage are examined, together with data concerning dimensions, speeds, power-consumption, and capacity.

Valves.

CRANE COMPANY, Chicago.—Catalogue of valves, fittings and appliances, including steam valves, check valves, pop safety valves, and steam fittings generally. Separators for oil and steam are illustrated, also steam traps, drip pockets, sediment traps, and power-house appliances generally.

Filing Machines.

THE SIMPLEX MANUFACTURING COMPANY, Granby, Conn.—Illustrated catalogue of the Simplex combination bench-filer and hack saw. This machine is intended to replace all hand filing by mechanical operations, while at the same time retaining all the flexibility and range of skilled hand work. The machine may be used for filing or for hack saw cutting simply by the change of tools, and is especially adapted to the use of the magazine hack saw in which a continuous flexible saw blade is applied. The capabilities of the apparatus are fully illustrated, and an extensive list of establishments in which it is used is appended.

Electrical Machinery

THE BARRIETT ELECTRIC MANUFACTURING COMPANY, Cincinnati, Ohio. Bulletin No. 5, describing Type E motors and generators for direct currents. Details of the armatures and brush holders are given, with illustrations of partially and fully enclosed motors, and tables of dimensions and ratings of the machines. The advantages of electric driving for machinery are set forth effectively, both as regards economy in transmission and operation, and in respect to cleanliness and freedom from danger.

Oil Engines

SAMUEL L. MOORE & SONS CORPORATION, New York.—Catalogue No. 1, describing the Crescent Oil Engine as designed for burning kerosene and the cheaper oils for stationary and marine purposes.

The Industrial Pacemaker

THE article in the present issue calling attention to the work of the rock drill in the development and extension and rapid upbuilding of the Greater New York naturally suggests a thought as to how great its work may be taking the whole world through. While the rock drill is here employed in the very front of our civilization it also seems to have its mission in pushing and speeding the rear of the always advancing column. The most remote, the most inaccessible and normally uninhabitable spots of earth are also where it has the habit of congregating. While the rock drill is so busy in New York, with so much work still crowding it, almost at the very antipodes is the spot where it would seem to be still more in demand. On "The Rand" in South Africa there are said to be 2400 rock drills at work, or more than on any other equal area in the world.

This statement becomes less gratifying when we are assured, as we are upon good authority, that the output of these antipodean drills is not what it should be, that in fact the drills do less than half what drills of the same capacity would do in, say, Colorado, the work in New York being of such a character as not to be fairly comparable.

A sufficient item of evidence as to the situation is in the low pressure of the air generally carried. *South African Mines* of Johannesburg, says—not precisely in these words—that pressures not exceeding 50 pounds are quite common, that, in fact, pressures maintained higher than that are the rare exception. There are also enormous leakages in the pipe lines and connections. A large portion of the air compressed is lost, so that of the horse-power developed and applied in the power houses not one-half of the power usually realized in such cases is operative and effective at the drills. The condition of the drills, the manner of their manipulation and their actual output all correspond with the rest of it.

This state of affairs seems to be chronic. There is no evidence that those in responsible charge or those most interested in the results are not as well satisfied as if everything was working at its best and the output the highest possible. The reason is apparently that they do not know any better. They are not in touch with the world's winning workers and do not know the gait. Each is doing about as well as the rest, so why should any of them do better?

Another view of the same conditions might be that each is doing as badly as the rest, so all are in need of reforming. "Darkest Africa" here becomes only typical industrially of too many others, and of many near home, who are not in touch with the times nor keeping step in the march of progress. The pacemaker is needed everywhere. In South Africa there are special labor troubles and unusually incompetent workers; other localities can offer other excuses, but as the South African excuse does not account for its low air pressures and its leakages, so incompetence falls short elsewhere.

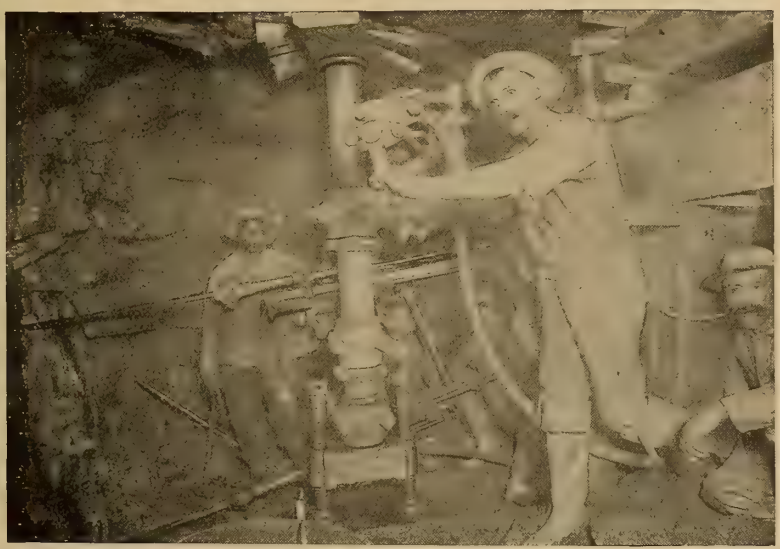
The work of the technical press in spreading wide a knowledge of the improved facilities, the advanced methods, the continually increasing outputs in the different lines of industry is perhaps best evidenced by the deficiencies and delinquencies in the regions beyond its present touch. Improved machine tools, high-speed steels, special machines for repetitive operations, electrically and pneumatically animated devices, command the possibilities; still it is the human element which assures the actual result. The speeds at which machines shall run, the continuity of their operation, the volume of their output comes of knowledge and determination in the operator, and these do not spring spontaneously out of the uninformed and unstimulated brain.

Rock Drills

THE "SERGEANT" (Independent Valve)

THE "LITTLE GIANT" (Tappet Valve)

The World's Standard of Rock Drill Excellence



Ingersoll-Rand Drills at work in a tunnel under the East River in New York City. On the subaqueous tunnel work in New York City over **350** Ingersoll-Rand Rock Drills and **93** Ingersoll-Rand Air Compressors are in service.

POWER ECONOMY.—The valve movement of Ingersoll-Rand drills gives the quickest admission, the freest exhaust and the least wear and leakage, meaning higher speed, a harder blow and a greater depth of hole drilled per cubic foot of air used than any other drill.

REPAIR ECONOMY.—The use of selected metals, the oil-treating of steel parts and the applied experience of thirty-seven years of drill building give Ingersoll-Rand drills an unequalled endurance and a repair economy unapproached by any other drill.

"CALYX" CORE DRILLS **AIR TOOLS** **AIR HOISTS**

INGERSOLL-RAND CO.

CHICAGO, CLEVELAND, SEATTLE, MONTREAL, PHILADELPHIA, HOUGHTON, SAN FRANCISCO, JOHANNESBURG, 11' BROADWAY NEW YORK, BUTTE, LONDON, SALT LAKE, BERLIN, ST. LOUIS, PITTSBURG, BIRMINGHAM, MELBOURNE, EL PASO, BOSTON, DENVER, PARIS

V25

Manila Rope

MANY of the materials employed in engineering work have been studied and investigated and the results recorded in such a complete manner that it is necessary only to turn to the textbooks to find out just what can and cannot be done with them, while other materials have to be tested and examined by the user with such means as may be at his command before he can feel justified in going ahead. An example of the former class of materials is found in structural timber. Different kinds of wood have different strengths and different kinds of strengths, one variety being adapted for uses for which another sort is wholly unfit, and while accurate testing is desirable in important structures an excellent knowledge of the strength of timber may be obtained by an examination of the published reports of tests.

In the case of rope similar differences exist, with corresponding effect upon the material. To many men all manila fibre is accepted as of equal strength, while in fact there are as many qualities of rope fibre as there are of structural timber. A rope which will do for a standing rigging may be unsuitable for hoisting or for transmission service, and the rate of bending as well as the size of sheave over which a rope is bent will have an important influence upon the strength and endurance. The qualities which conduce to strength and durability in manila rope have been investigated in the course of practical experience, and nearly all the reliable knowledge available about such rope is based upon the observation of the engineers and manufacturers by whom it has been employed.

When a rope is bent over a sheave of moderate or small diameter, under load, the fibres near the exterior are extended and compressed so that they slide upon the fibres about the centre. This action causes an internal movement of the fibres of the rope upon each other and the consequent wear gradually grinds a portion of the interior of the rope to powder, so that a rope may look quite perfect on the outside and be gone in the interior. If such a rope be cut in two the core can be shaken out in the form of a fine powder. This wearing action is difficult to detect, since the outside of the rope appears perfect long after the core is gone. The best prevention of this internal grinding action is to have the rope laid up with an internal lubricant in the form of plumbago and tallow, so as to fill up the inequalities in the fibres and permit them to slide freely upon each other without appreciable wear. A rope thus treated becomes practically waterproof and extremely durable, being protected both against internal chafing and against rot.

A manila rope, properly laid and lubricated. is as strong, weight for weight, as steel; that is, a steel rod weighs about eight times as much as a manila rope of the same diameter, and has about eight times the strength, the strengths being proportional to the weights. When used for transmission purposes it has been found that a manila rope 1 inch in diameter is equal to a double leather belt $2\frac{5}{8}$ inches in width, so that three such ropes are very nearly equal to an 8-inch double belt. A 2-inch rope will transmit as much power as a 10-inch leather belt, while the loss from stiffness and creep are estimated as only about one-half with the rope what they are with the belt.

In order to obtain satisfactory results with rope transmission it is necessary that the system be laid out with proper knowledge and judgment. It is as much of a mistake to suppose that a successful rope transmission can be put up at random as it is to treat any other engineering problem in such a manner. The sheaves must be of the right size, and the speeds and the loads must be right, and then the whole job will be right if the rope is properly made of the right kind of stock.

Manufacturing News

Mechanical Time Recorders

TO fill the continued and increasing demand for an instrument which makes a graphic record of variations and the time of such variations, of mechanical movements, The Bristol Company, Waterbury, Conn., have placed on the market the instrument illustrated herewith, to which they have given the name Mechanical Time Recorder. A circular chart revolves by clock work at uniform speed, while the pen moves over the chart an amount proportional to the motion to be recorded.

The chart is eight inches in diameter, being the same size as on the well-known standard Bristol gauges.

Clock movements can be supplied for complete revolution of chart once in 15 minutes, 1 hour, 2 hours, 3 hours, 4 hours, 6 hours, 8 hours, 10 hours, 12 hours, 24 hours, or 7 days.

Thus it will be seen that the speed may be selected to give best results under all commercial requirements.

The pen arm is rigidly attached at its lower end to a shaft which is turned by a short arm projecting through a slot in bottom of the case.

The lever shown in the cut projecting to the right, is clamped to the short arm by a thumb nut. Special attention is called to the fact that this lever is adjustable and can be

A MECHANICAL TIME RECORDER.

clamped to the arm at any convenient angle.

The motion to be recorded after being properly reduced, if necessary, is imparted to the lever which in turn transmits it to the pen.

The total scale on the chart is usually taken proportional to the total motion to be recorded. Reduced motion, if necessary, can easily be arranged by the aid of pulleys, levers or other reducing devices.

Fine adjustments can readily be made by applying the motion at the proper point along the lever, and to facilitate this, a metal attaching piece is provided, which is adjustable on the lever arm and secured in any position by thumb nut. It will readily be seen that by the aid of the adjustable lever arm and the adjustable slide on the arm, the instrument is most conveniently adapted to record motions of all amounts and directions.

Total deflection of the pen is obtained by turning the lever through an angle of about 21 degrees or 5 inches motion at its outer end.

This instrument can readily be used to record the rate of motion and position of sluice gates, turbine or engine governors, gate valves, etc. It is also adapted for recording the rise and fall of liquids in tanks, rivers, reservoirs and forebay.

In the gas industry it can be used to check up the operators and thus prevent the "blowing" of the holders either day or night. Its applications are, however, so many and varied that it is difficult to mention them even for a single industry.

Ejectors as Elevators and Conveyors for Liquids

WHEN liquids are to be handled at a moderate outlay for the original equipment, and where the conditions do not warrant the installation of a steam pump, one of the best plans is to use an ejector. This convenient appliance has a large field of usefulness, and on account of its compactness and portability it is meeting with extending success, and becoming a substitute for steam pumps, syphons, and similar appliances.

PENBERTHY "XL-96" EJECTOR.

It would be difficult to enumerate all the uses to which an ejector is adapted, but when we say that anything and everything in the nature of a liquid (if not too thick) can be transported from one level to another, or horizontally any reasonable distance, the ground is just about covered.

Take, for instance, such plants as breweries, chemical houses and other concerns using heated liquids, the "XL-96" Ejector is indispensable and unrivaled in its simplicity of operation. It is also an unexcelled agency for raising liquids from wells, tanks, mines, vessel holds, docks, etc.

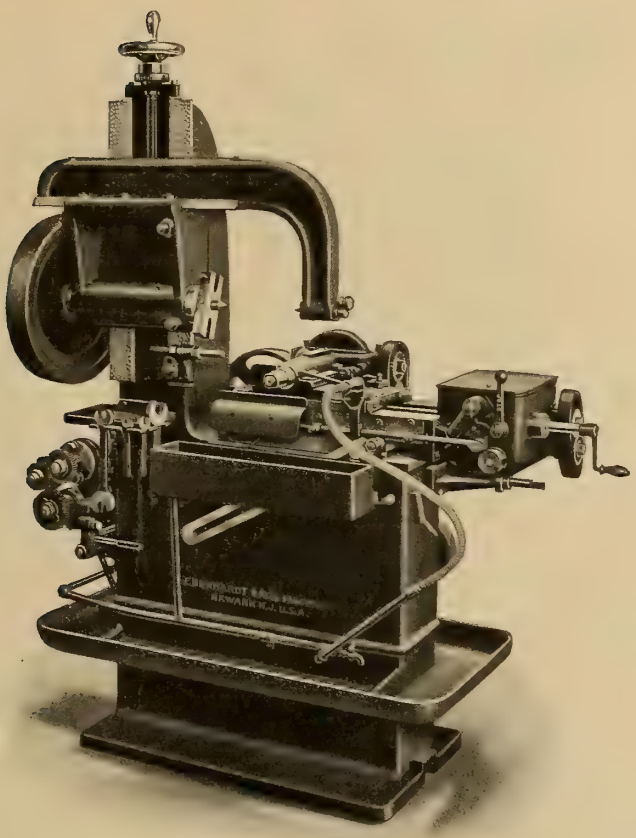
Distilleries, creameries, tanneries, dye works, paper mills and plants of like character employ them almost entirely for raising and syphon purposes.

Complete information as to the "XL-96" Ejector and its uses may be obtained by writing to the manufacturers, Penberthy Injector Company, Detroit, Mich.

Automatic Gear-Cutting Machine

THE illustration shows an improved automatic gear-cutting machine for spur and bevel gears, designed and manufactured by the Eberhardt Brothers Machine Company, of Newark, N. J.

The machine is suitable for such work as lathe and milling machine change gears, feed and adjusting spur and bevel gears, milling of face clutches, cutters and saws, and, in fact, all cylindrical or conical work requiring automatic milling, where



EBERHARDT BROS. MACHINE COMPANY, AUTOMATIC GEAR-CUTTING MACHINE.

either accuracy or rapid production, or both, are essential.

The machine has a capacity of 24 inches diameter, 6 inches face and 8 inches diametrical pitch in steel at a good feed. The construction follows the general design of the line of machines of this company, except where the size of the machine allows of different applications of the same principles. This is shown in the bevel-gear drive to the cutter spindle, providing a very efficient drive, especially adaptable to the high spindle speeds required by high-speed steel cutters. The changes of spindle speeds are obtained by means of gears, immediately driving the bevel pinion.

A segment graduated in degrees provides for cutting bevel and mitre gears. The segment is operated by means of a worm, meshing in the teeth in its periphery, thus allowing convenient adjustment. The slide can be raised to 90 degrees, and the machine is very suitable for such work as milling face clutches, etc.

A strap is shown in the front view of the machine, which is used as a brace to give additional stiffness to the slide when raised.

A screw is provided for adjusting the lower slide toward or from the column to allow for different lengths of hubs. A dial, graduated to thousandths, facilitates this setting. Graduated dials are also provided on the indexing worm, and on the cutter spindle bearing for rolling and shift-

ing when cutting bevel and miter gears, and on the depth adjusting screw for setting the proper depth to be cut.

The indexing mechanism is positive and operates the master wheel, which is large for this size machine, as can be seen.

The outside support to the work arbor is adjustable for different lengths of arbors, but is always centered opposite the work spindle. This is especially convenient in a machine of this class and allows rapid setting.

The cutter arbor is solid with the cutter spindle on this size and takes cutters with 1-inch hole. The chips are caught in the box on the side of the machine, and the oil runs through, being caught in the ample reservoir formed around the frame of the machine. The oil pump affords a constant stream of cutting lubricant and can be adjusted to regulate the supply.

An Improved Double Circular Saw

A COMBINED rip and cross-cut saw constructed on distinctly different lines from anything heretofore offered the woodworking trades has just been placed on the market by a Cincinnati firm.

In the design and construction of this machine extreme care has been given to every detail in order that the work it is intended to do will be absolutely accurate.

The frame is a massive casting heavily ribbed throughout and with the metal so distributed as to resist all strain and to eliminate all vibration.

Both saw arbors are carried on a revolving frame whose bearing at the front consists of a circular plate 20½ inches in diameter by 1¼-inch face, set in a turned seat in the front of the column and secured by a set of gibs. This feature is an important one, since it does away with the outside support and wall of the column in front of the saws, as is the usual order in a tool of this kind.

This improved feature makes it easy to put on or take off saws without disarranging the table.

Then again, by the use of this revolving plate, the front of the column is entirely closed, keeping the mechanism inside free from sawdust.

By the use of this plate two saws up to 16 inches in diameter (one on each arbor) can be carried at the same time and the frame revolved, or if only one saw is used it may be as large as 20 inches in diameter.

The placing of this plate between the saws and the driving pulley makes the revolving frame very rigid where rigidity is most needed.

The binder frame, carried on the inside of the column, is used in belting the machine either from above or under the floor. It is hung in such a way as to have the greatest pressure on the slack side of the belt.

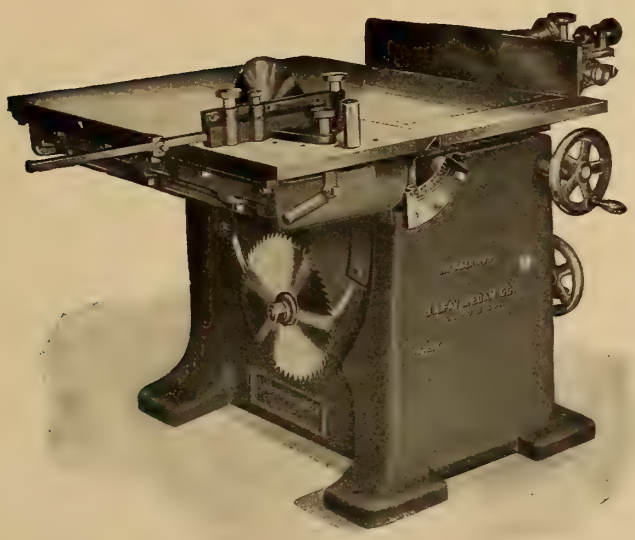
The table is made in two sections, a moving section 44 by 16 inches, moving easily on frictionless rollers, and a stationary section 44 by 20½ inches, the latter having an extension so that material up to 20 inches in width can be ripped. The rollers under the moving table are held in a frame and run on a track made adjustable for wear. This section of the table has sufficient movement to edge or cut off material up to 35 inches.

The moving table will open to permit the use of a 2-inch grooving head.

The whole table can be tilted to an angle of 45 degrees from the saw by a hand wheel operating worm and gears and connected to the table itself, making a self-locking arrangement.

A gauge on the column registers the angle to which the table is tilted.

The ripping fence may be set to rip stock up to 20 inches wide and may be used either on the right or left section of table; when used on the latter section it forms a support for the stock when the table is tilted; this is a decided advantage in working heavy material. It can be firmly



DOUBLE CIRCULAR SAW BENCH. J. A. FAY & EGAN CO., CINCINNATI, OHIO.

secured at any angle not in line with the saw by simply using one of the taper pins as a center. This permits the use of the periphery of the saw to cut semi-circle core boxes of any size. At the right of the saw, on the stationary table is a plainly stamped index of small gradations for use with the ripping fence.

Two universal fences graduated to angle 60 degrees to right or left are furnished regularly with the machine. Slots or ways are planed the entire length of table for the use of these fences.

Square slots are planed in the face of each fence for stop-rods to be used as a gauge in cutting off pieces of different lengths.

The miter cut-off fence is used on the sliding table and covers a range from 45 degrees back of the fence to 60 degrees in front, as shown in illustration. This is furnished with a stop-rod to be used for stock of various lengths.

Particulars of the above machine can be had by addressing the J. A. Fay & Egan Company, 226-246 West Front street, Cincinnati, Ohio.

The Dewey Decimal System

THE Engineering Experiment Station of the University of Illinois has recently issued Bulletin No. 9, "An Extension of the Dewey Decimal System of Classification applied to the Engineering Industries." This bulletin is in effect a fifth edition of the extension previously issued by the mechanical engineering department. It contains the extensions previously worked out for mechanical and railway engineering, and in addition, a very complete extension for electrical engineering, and more or less complete extensions for bridge engineering, sanitary engineering, metallurgy and architecture. An alphabetical index of subjects adds to the usefulness of the classifications.

Bulletin No. 9 extends the work of Mr. Dewey to practically all fields of engineering industry, and presents a system of classifications of great value to engineers and those engaged in engineering industries. Copies may be secured by application to the director of the Engineering Experiment Station, Urbana, Ill.

News Notes

MESSRS. H. M. BYLLESBY & Co., of Chicago, have been retained as consulting and supervising engineers by the Mobile & Ohio Railroad Company, for the rehabilitation and electrification of their general repair shops at Whistler, Ala. The same firm has also been retained as consulting engineers for the Sioux Falls Light & Power Company in connection with the development of a water power plant on the Big Sioux River. Another important work in charge of this firm is that of the Flathead Valley Water Power Company, of Kalispell, Mont. This company has a water-power plant operating under a head of 105 feet on the Big Fork River, at Big Fork, Mont., the capacity of which is to be greatly increased.

MR. F. A. WALDRON, Mem. Am. Soc. M. E., well known in connection with the development of the power plant of the Yale & Towne Manufacturing Company, and later of the National Cash Register Company, of Dayton, Ohio, has opened an office as consulting engineer at No. 37 Broad street, New York.

THE CUTLER-HAMMER MANUFACTURING COMPANY, of Milwaukee, Wis., makers of electric-motor controlling devices, announce the purchase of the Wirt Electric Company, and state that the manufacture of the Wirt apparatus will be continued by them. Pending the incorporation in the Cutler-Hammer catalogue of apparatus of the Wirt type, the current Wirt catalogue should be used. Copies of this catalogue may be obtained from the Wirt Electric Company, Philadelphia; the Cutler-Hammer Manufacturing Company, Milwaukee, or on application to any of the district offices.

The purchase of the Wirt Electric Company will enable the requirements of the trade to be met more fully than ever before. For many years certain types of Wirt apparatus have enjoyed an enviable reputation. Particular attention is called to the very complete line of battery charging rheostats developed by the Wirt Company, and to the Wirt field rheostats, which in 1902 were awarded the John Scott medal on recommendation of the Franklin Institute of Pennsylvania. Bulletins covering these and other lines of Wirt apparatus will be furnished on application.

JOHN A. WALKER, vice-president and treasurer of the Joseph Dixon Crucible Company, died at his home, Jersey City, N. J., on May 23. Mr. Walker was born in the city of New York, Sept. 22, 1837. He received his early education in the schools of Brooklyn, and, although prepared for college in a private school, chose commercial life. After an excellent business training in the city of New York, and after serving his country in the civil war of the South, Mr. Walker, in 1867, became connected with the firm of Joseph Dixon & Co., of Jersey City. In 1868, when Joseph Dixon & Co. became incorporated as the Joseph Dixon Crucible Company he was made secretary of that company and began his life-work in making known to the world the many uses of the then but little known form of carbon,—graphite, of which the Joseph Dixon Crucible Company have been the best and most widely known exponents.

Mr. Walker served the Dixon Company as secretary and largely as manager until 1891, when he was unanimously elected to the dual position of vice-president and treasurer, the latter office having been held by him for some time previous. He held these offices without interruption until his death, the general management of the company also being largely in his hands.

RECENT CATALOGUES

Gas Engines.

The De La Vergne Machine Company, New York.—Two catalogues illustrating and describing the Koerting two-cycle and four-cycle gas engines as built by the American representatives of the well-known German firm. These are handsomely illustrated books, giving detailed explanations of the construction and operation of the engines, their mechanical advantages and their high thermal efficiency. Data concerning suction and pressure gas producers are included, together with useful tables and information relating to the production and use of gas for power production.

Flanges.

American Spiral Pipe Works, Chicago.—Catalogue of forged and rolled steel pipe flanges, containing a discussion of the advantages of steel flanges for high-pressure steam connections, tables and data of the different standards, together with full-sized sections of the various flanges. These flanges are arranged for riveting to pipe or to boiler shells, also for welding to pipe, or are furnished with standard pipe thread. The tables and diagrams of dimensions are very complete, enabling the engineer and designer to include such flanges in drawings and plans for work of every class.

Tools

Pratt & Whitney Company, Hartford, Conn.—Convenient catalogue and list No. 4 of small tools, standards, and gauges, including taps and dies, milling cutters, lathe tools, twist drills, reamers, etc. This very complete book of more than 200 pages contains tabulated data of a great variety of small tools, adapted for all kinds of machine work, representing the products of this well-known shop. Milling cutters and reamers of all styles are especially well represented, also steel caliper gauges, limit gauges, standard plugs and rings, measuring machines, etc. Tables of screw threads, tapers, wire gauges, and equivalents add to its value for reference purposes.

Hoisting.

Lidgerwood Manufacturing Company, New York.—Descriptive pamphlet of Lidgerwood electric hoisting engines, with illustrations showing the application of electric motors to the various types of Lidgerwood hoists. These are adapted for contractors' work, for railroads, docks, or quarries, and afford means of equipping derricks with power-hoisting machinery wherever electric current is available. The hoists are arranged with direct-current motors, for current from 250 to 500 volts, the motors being enclosed and fitted with controllers and resistances, while the hoists may be fitted with solenoid brakes, in addition to the regular band brakes, when so ordered. Double and single drum hoists are shown, enabling every kind of service to be met.

Locomotives.

Baldwin Locomotive Works, Philadelphia, Pa.—Record No. 61, being a handsome reprint of the article on the "Steam Locomotive of the Future," by Mr. Lawford H. Fry, originally published in Cassier's Magazine in January, 1907.

Dust.

Barrett Manufacturing Company, New York.—Excerpts from an address before the American Road Makers' Association, by J. W. Howard, upon the use of tar for the prevention of dust upon roads, and discussing especially the advantages of the special tar preparation known as "Tarvia."

Partners of Providence

ONE of the most striking of the titles of the new books of the day is the above. This book, by the way, is so good all through that it is a pleasure thus to allude to it.

Providence seems to be run, at least in the details of it, entirely through partnerships, although so often these partnerships are not recognized as such until long after the event. One of the frequently remarked phenomena accompanying our progress in engineering and mechanical achievement is the closeness with which the development of new means and methods and the production of the new materials are followed by new employments, new applications, new products or results. Between them it is by no means easy to determine which is the predecessor, which is the cause and which the effect. Indeed, they often change places. Sometimes an invention does, as we say, "fill a long-felt want," but quite as often it reveals and creates a want.

Demand may stimulate supply, but supply also may beget demand.

The modern bicycle when it came, as it did, with a rush was an embodiment of many then recent ingenious inventions and of many new refinements in the production of material. If any daring inventor could have imagined a bicycle only a quarter of a century before it appeared so suddenly, and as it was when it appeared, it would have been impossible to have produced it for him at any price. We had not the cheap, reliable mild steel, the seamless steel tube, the ball bearing or the balls for the bearing, the pneumatic tire, and especially we had not the automatic, repetitive, precise machinery of manufacture. Until the existence of these was successfully revealed to him the inventor could not have done his inventing any more than the builder could have produced the machine.

Tin is a metal of the greatest importance in a wide range of industries. Its uses and applications are so varied that innumerable and most diverse activities would be crippled if the world's supply of it should give out, and yet this supply has always been precarious. It is produced in relatively small quantities in most remote regions, and while the price of it puts it almost among the precious metals the production of it has never been more than fairly profitable. Great fortunes have been made in almost any other line rather than in this. Search has continually been made for new deposits which might be worked to advantage. It appears that extensive and more than promising fields of tin are revealed in Alaska. At the very narrowest point of Behring Strait, and precisely over the line of the proposed tunnel which is to connect the oldest of the continents with the newest, Calyx drills are figuring as Partners of Providence, industriously multiplying borings which reveal the location and the richness of the coveted deposits.

The Partners of Providence thus working on the shores of Alaska are pioneers, leading the way for the large and complicated plants which are ultimately required for the production of tin in quantity; in the case of the North River tunnels of the Pennsylvania Railroad, these same Partners of Providence come in to aid in the completion of a monumental and epoch making enterprise. When these tunnels are completed and safely and confidently operated and the engineers in charge have sufficient leisure to tell in detail of the novel conditions of working and the unexpected difficulties encountered, the world will come to a higher appreciation of the enterprise, the skill, the perseverance which wrought success and the Partners of Providence who assisted, even to the last of them, in this case apparently the Calyx drill, will not fail of recognition.

Manufacturing News

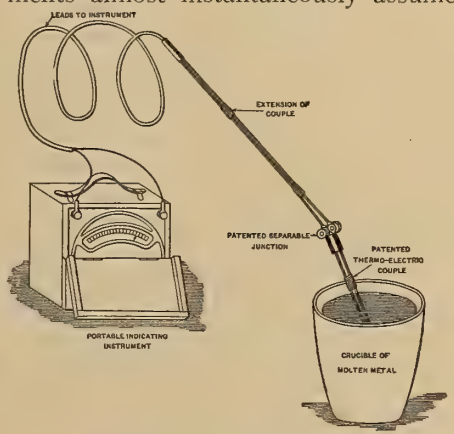
A Portable Pyrometer for Molten Metals

IN manufacturing processes and in metallurgical work molten metals and alloys are extensively employed, especially for the making of castings from moulds, and it is of the utmost importance that the metals be mixed, alloyed and poured at the proper temperatures in order to obtain the best results. The special form of pyrometer described here has been designed to meet the practical requirements of every-day shop practice. The portable indicating instrument may be carried in the hand and within two or three seconds the temperature of the molten metal may be taken. The possibilities and great value of an instrument of this kind will be fully appreciated by those who are interested in foundry work of any description.

The outfit complete consists of a portable indicating instrument connected to a special thermo-electric couple, the two elements of which are disconnected and left without insulation. When the tips of these elements are slightly immersed into the molten metal an electric connection is made and the reading on the instrument will be the same as if the couple had been originally joined.

The general arrangement of the parts forming the outfit for this class of temperature measurements is shown in the accompanying diagram as it would be applied for taking the temperature of a crucible of molten metal just before pouring.

The advantage of this plan is that the tips of the wires forming the elements almost instantaneously assume



THE BRISTOL PORTABLE PYROMETER

the temperature of the molten metal and the time-lag error is eliminated.

This form of couple has been most successfully applied to the measurement of molten metals as cast iron, copper, aluminum, brass, bronze and other alloys.

These instruments are being successfully used by a large number of manufacturers.

They are manufactured by Wm. H. Bristol, 45 Vesey Street, New York City.

The Development of New Names

WE don't always realize our responsibilities at critical moments. The making or placing of names for new things is a case in point. The Linotype people, we understand, continually regret that the name of their modern mechanical wonder is not pronounced as they intended and therefore does not carry to the public the essential idea intended to be conveyed. The work of the machine, as we all know, is to cast a line of type, and the name was meant to be line of type, line-o'-type, lineotype. Unfortunately, perhaps some "simplified" speller had a hand in it, the letter "e" was left out of the middle of the word and it is often pronounced, with dictionary authority, too, as if it was spelled linnotype, with the first syllable short, and the basic idea consequently is lost.

Another case, in which, however, the conditions are as different as can be, is that of the Electric-Air rock drill. Here also there has been the intent to produce a name which would correctly characterize the thing, and here also the result has been anything but a success. The name certainly carries its suggestions. There are electric drills and there are air drills. The friends and promoters of the Electric-Air drill might, from the name, claim for it all the good qualities of both, and the enemies and competitors of it might say that it embodies all the objectionable features of each, but either way of taking advantage of the name would upon investigation fail, for the name is a double misnomer. It might quite truthfully be said that the Electric-Air drill is apparently so called because it is neither an electric drill nor an air drill. It certainly is not an electric drill, as the electric current does not come in contact with the drill in any way, nor within several feet of it, and while the actual electric drills which have been tried have made such a poor show in the world it is a heavy handicap on a new drill to have the same family name. So, too, the drill is not an air drill, as such drills have heretofore been known, with the piston driven alternately in one direction and then in the other by direct air pressure, and the air for each stroke at once exhausted into the atmosphere. The action of the air in this drill is so different that the fullest knowledge of the regular air drill is, to the extent of its completeness, a disqualifier for a correct understanding of this.

Then, again, the little portable electrically-driven air compressor which is a part of the apparatus of each Electric-Air drill is not an air compressor, and its name is another misnomer. That is, it does not do what an air compressor is understood to do. It does not take in successive charges of air from the atmosphere, compress the air and pass it along and then take in more, and so on. It plays the same air back and forth and is in fact a pulsator rather than a compressor, and, not being a compressor, neither the good nor the bad qualities of a compressor are properly assumable for it in consequence of its false name.

This apparatus is so novel and revolutionary, and promises to make for itself such a place in the industries of the time, that it deserves a new and distinctive name all its own, quite as much as did the Kodak. It is no wonder that the dictionary grows and that, after all, it is always behind. New things spring into being to which none of the old names fit, and so there must be new ones continually. Things which do things, things which have to be talked about, develop handy names of their own, and we may expect one before long for the Electric-Air drill. The little motor boats on the St. Lawrence are locally known only as "put-puts."

Manufacturing News

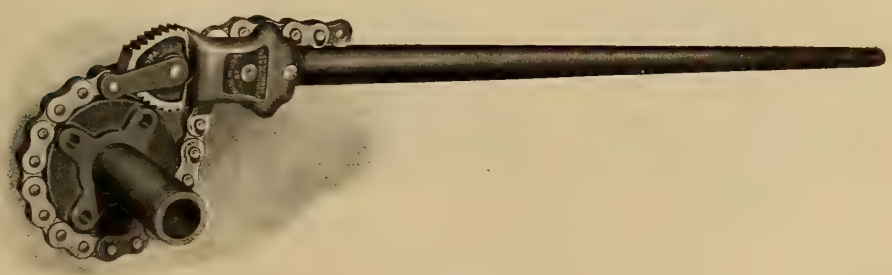
An Improved Wrench for Pipe-Fittings

IN handling pipe fitting there are numerous places in which the ordinary type of wrench cannot be used with convenience or success, and something better is demanded. We illustrate herewith an improved form of chain-wrench, for especial use upon fittings, flanges, nipples, etc., this tool bearing the name "Agrippa," and being manufactured by Messrs. J. H. Williams & Co., Brooklyn, N. Y.

This wrench is especially efficient on short nipples, flanges, and in such places where limited space does not permit the use of a wider or a double-jawed wrench, and, as the illustrations clearly show, the space required is but little more than the width of the chain.

The long experience of the manufacturers in the design of tools of this kind has been brought to bear upon the production of this wrench. It is made of materials of the highest class, the wrench being entirely for wrought steel, drop-forged and saw tempered. The jaw is permanently fastened in a milled pocket in a solid-forged steel handle of ample strength. A greater length of chain is furnished than in the case of wrenches intended for use upon pipe only, thus enabling flanges and similar parts to be handled. The chain itself is hand made, and especially strong, and the wrench can be used from either side of the jaw instantly.

These wrenches are made in seven sizes ranging from $\frac{1}{8}$ to 12 inches in capacity, thus enabling flanges and fittings of a wide range of sizes to be handled.



THE AGRIPPA PIPE FITTINGS WRENCH. J. H. WILLIAMS & CO.

Power Economy in Return Air

IN learning to use compressed air economically the same course has been traversed as in the use of steam, although the lesson having been first and completely learned with steam as the motor-fluid, it might have been expected that once thus learned it might have been much more quickly appropriated by the users of the air. Steam was first used to fill a cylinder or other chamber, at full pressure, and to do what work it was capable of at that pressure, and then it was discharged at that full pressure into the atmosphere, or into the condenser. Steam so used was the passive transmitter of the pressure in the boiler, and itself really did no work. The use of steam expansively, allowing its elasticity materially to augment the total of work accomplished, was a later achievement.

So when compressed air is applied, in what has been the usual way, to the operating of the familiar apparatus, to the rock drill, the direct air hoist, or even in driving a steam pump, the air, which is so useful at full pressure and is then discharged, actually does no work with which it may itself be credited. A passive column of it is simply pushed along by a force behind it, either actually by the compressor itself, or by the slight expansion of the large body of air in the receiver and mains, and this notwithstanding the fact that the air, each individual cylinderful of it, is capable of doing work by its expansion all the way down to the pressure of the atmosphere into which it is finally discharged.

We may believe that the great gains accomplished by the use of steam expansively were not ignored by the earlier users of compressed air, the simple fact being that while they would gladly have saved the wasted power, they did not at first, nor for a long time, see the way to do it. Compressed air has been many times employed for forcing water to higher levels. With a chamber full of water, and a discharge pipe leading up to the height at which it was desired to deliver the water, air of sufficient pressure would be admitted to the chamber above the water, and the air would drive the water up the pipe. When the operation was completed the chamber would be full of compressed air, and then the question would come up as to what could possibly be done with this air except to discharge it into the atmosphere so that the chamber might fill with water again, and as no answer was forthcoming the air would be so discharged and all its expansive force would be wasted, this practice ruling from the very earliest use of compressed air until a device, which in principle is extremely simple, completely solved the perplexing problem. The return-air pumping system, instead of discharging the air at its full pressure, pipes it back to the intake of the air compressor; in its reexpansion this air helps the compressor piston to do its work, and this help reduces to that extent the power-cost of compressing the air to the pressure required for forcing the water.

The electric air rock drill, another quite recent invention, is a return-air apparatus which accomplishes results still more astonishing in the way of power economy in the use of compressed air. It transforms the extravagant wastefulness of the familiar air-driven rock drill into the completest economy in the transmission and application of power, under most difficult and exacting conditions. In this case not only is the elastic force of the air entirely utilized, but there are no losses in the filling of clearances, and the cushioning of the piston is only a carrying over of force from one stroke to the next.

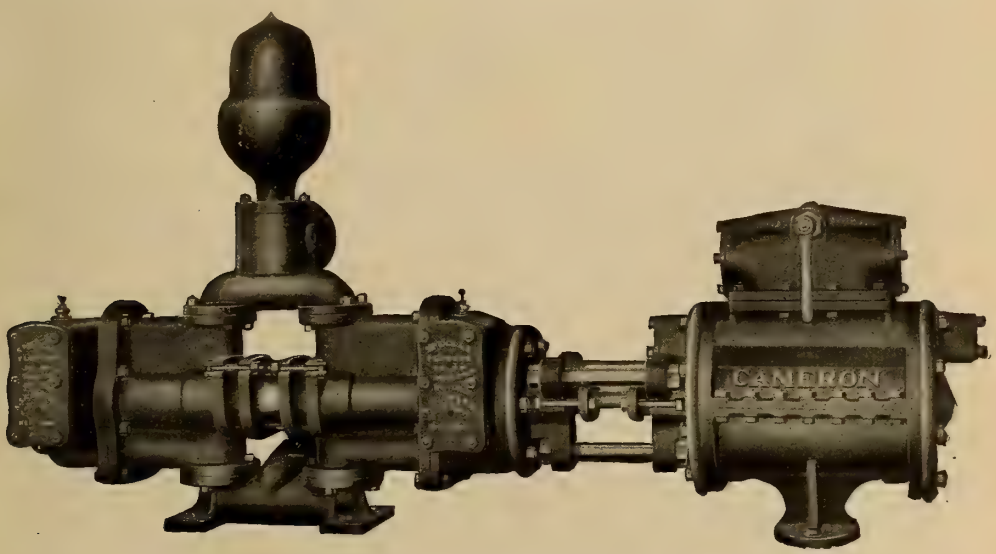
It is evident, therefore, that the development of efficiency in the use of compressed air has attained a point impossible with steam, since practically all the energy contained in the exhaust is returned to the compressor.

Manufacturing News

Methods of Transporting Mining Machinery in Mountainous Countries

AMERICAN capital is being constantly invested in the many promising enterprises throughout Mexico, Central and South America. Only recently the United States Consul General of Mexico estimated that during the last four years, $125,000,000 of American capital had been invested in the mines of Mexico alone, while in other industries the investments are also very large; which is also true of the other countries referred to.

The greatest percentage of capital, however, is invested in the mining industry; as indeed it was owing to the discovery of precious metals in the various parts of these countries that led settlers to discover the other resources; thus, new settlements, mining camps and towns were created and are growing rapidly with the new industries.

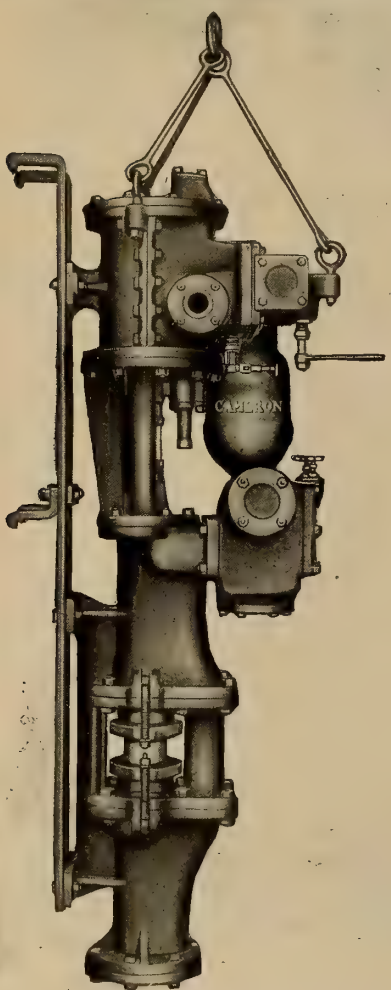


MINE STATION PUMP; SECTIONALIZED MOUNTAIN PATTERN

In the development of all of these industries, there is a constant demand for new machinery and equipment, and the larger portion is being supplied by American manufacturers. In the interior and in the mountain-

ous districts, there are still a large number of mining camps without close railroad facilities; and in some places the settlements are many miles from a railroad station.

The transportation facilities are very costly and the methods, in many



SECTIONALIZED SHAFT-SINKING PUMP; KNOWN AS THE SIERRAS TYPE

places, are very crude; in some parts the transportation of merchandise and machinery is carried on by the use of ox-carts; although in Western Mexico, where the mining industry is extensive, the Mexican burro, or donkey, is a most important factor, and is preferred on account of its being a swifter carrier, and safer in the dangerous mountain passes.

Thus the traffic between the railroad stations and the interior points is very largely handled by burro transportation. These little animals are worth from $12.50 to $20 each, United States currency. They average about 500 pounds in weight and will carry weights up to 300 pounds, traveling from 20 to 40 miles per day, according to the condition of the country.

The class of machinery used in these mining countries is often specially built to suit the mode of transportation; and in order to transport by mule teams, must be designed and built to allow for dismantling, so as to form a load of moderate weight for these animals to carry.

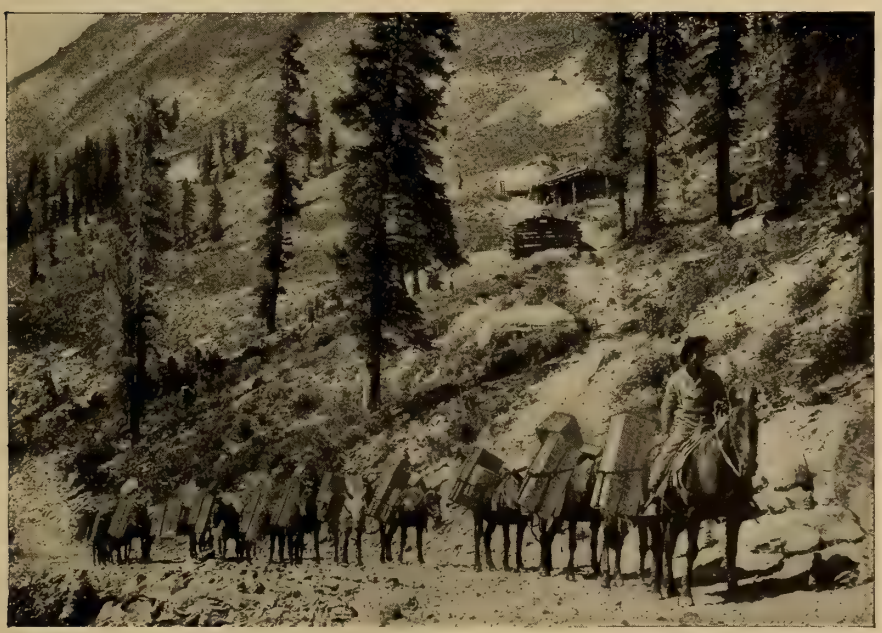
We are showing herein, by courtesy of the A. S. Cameron Steam Pump Works, several photographic reproductions of mule teams loaded with sectionalized Cameron pumps, also illustrations of these pumps as they appear when put together. These designs of pumps have been adopted almost exclusively for the mountainous regions, and have found their way on mule back, and sometimes by more primitive modes of transportation, over the mountain passes and terraced ranges of our own country and old Mexico, Columbia, Peru and Chili, as well as into other mining regions of Central and South America.

These types of Cameron mine pumps are built for the heavy work and rough services which they are usually subjected to in mining work. They are built in sections, the parts being so designed and proportioned that the pumps can be taken apart at the bolted joints and packed for shipment. The majority of pieces weigh less than 150 pounds, while the maximum weight, 300 pounds, is rarely found, and only in the larger sizes. The parts are so arranged and marked that they can be readily assembled and the pump set up without the aid of a skilled mechanic; and

TYPICAL MEXICAN BURROS

every pump that leaves the Cameron Works, in New York City, is thoroughly tested to a degree far in excess of its rated capacity.

The Cameron shipments from New York, destined for long journeys, are arranged for convenient handling and strongly and securely boxed, on account of the numerous transfers of freight in steamship and railroad traffic before they reach their ultimate destination. The arrangements for mule-back transportation must usually be made at some convenient station on



MULE TEAM CROSSING ROCKY MOUNTAINS

the line of a railroad or other carrier, the cost for transporting the material by burro train varying in proportion to the distance to be traversed, scarcity of animals, and the character and conditions of the country. Where the mountain passes to be traversed are narrow and dangerous, the loads are lightened as much as possible; oftentimes the boxes may be discarded and the machinery fastened on the back of the mule or carried in bags. It is sometimes necessary, when crossing steep and narrow mountain passes, to strap sticks to both sides of two mules, and place the load between the two.

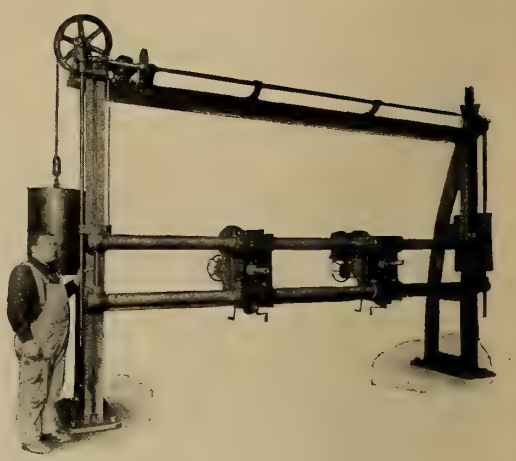
The burro is also an important factor in connection with the mining industry as an all-carrier, and burro trains are loaded up at the mines for return trips, thus taking material to and fro, the ore being held in leather pouches or bags.

The "Dallett" Motor-Driven Boiler Shell Drill

WE illustrate herewith a new boiler shell drill built by the Thos. H. Dallett Company, of Philadelphia, Pa. This machine is motor-driven throughout, and has been designed for the special purpose of taking advantage of high-speed steel, and as shown in the accompanying cuts represents the latest development in machines of this character.

As will be noted, there are two end housings, on the front face of which, carried by brackets, are two 5-inch bars, on which are mounted two independent motor-driven drill-heads balanced by the two counterweights, having a vertical range of 6 feet and raised and lowered by means of screws actuated by a motor on the top rail of the machine, this motor being handled by a reversible regulator on the inside of the housing, which does not appear in the cut.

An especially noteworthy feature



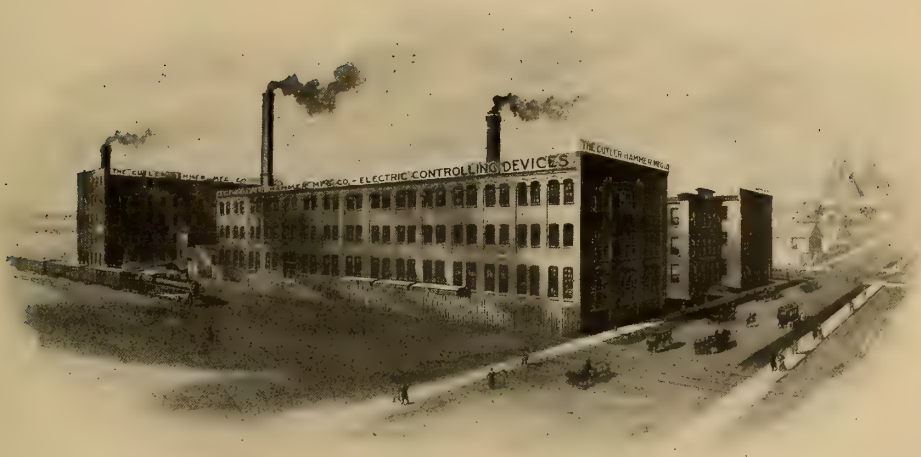
THE DALLETT BOILER-SHELL DRILL

of this machine is the central position of the spindle, not only between the bearings of the drill-head on the bars, but also between the bars, so that the pressure of the drill against the work has no tendency to set up torsional or sidewise strains in the drill-head or bearings, causing excessive friction of the drill in the hole, rapid deterioration of the drill and undue consumption of power, owing to the spindle being thrown out of alignment, as must be the case where a drill spindle is not central of its support.

The machine is entirely self-contained, all adjustments being effected by means of crank handles and hand-wheels, no wrenches whatever being required, and the operator has all the adjustments of the drill-head at his command from either side of said drill-head without moving from his position.

In the lowest position of the carriage, the centres of spindles are 21 inches from the floor, and in its highest position, 7 feet 6 inches. The distance between the housings is 14 feet, and the distance between spindle centers when the drill-heads are in their outmost position is 12 feet.

The length of the standard machine over all is 17 feet 8 inches; the height, 11 feet 6 inches, and the total weight 12,000 lbs.



PLANT OF THE CUTLER-HAMMER MFG. CO., MILWAUKEE, WIS.

Controlling Devices for Motor-Driven Machinery

IN the real estate section of a Milwaukee newspaper it is stated that the Cutler-Hammer Manufacturing Company, of that city, has recently purchased and remodeled, for manufacturing purposes, a five-story building adjoining the city block occupied by their factory. The growth of this business,—now the largest of its kind in the world,—emphasizes the modern tendency towards specialization.

This company for sixteen years has devoted itself exclusively to the manufacture of electric controlling devices. It makes neither motors nor generators, nor any appliances for electric lighting (except theatre dimmers), but in its chosen field—electric control—its various lines of manufacture are now so numerous that a catalogue of 300 closely printed pages suffices to list standard apparatus only, making no mention of the numerous special appliances it is constantly being called upon to design and build, to meet requirements not fully provided for in standardized apparatus.

Makers and users of motor-driven machinery, central station managers, consulting engineers, electrical contractors and others will be especially interested in the Cutler-Hammer Manufacturing Company's offer to render freely all possible aid in the solution of difficult problems involving applications of electric control.

Having devoted themselves for years to work of this nature and having accumulated a vast and valuable collection of data, they are in many instances able to find in their files problems identical with or closely resembling those that they are continually being called upon to solve. In cases where the problem submitted is absolutely new their engineering department works out the details, and this data is, in turn, filed for future reference.

In a recent announcement they state that they are daily in receipt of letters from all parts of the country asking how best to accomplish this or that result, adding:—"Many of those who consult us are quite capable of working out their own problems, but it saves time to 'ask Cutler-Hammer,' and to a busy man time is money."

Gas Engine Plant for the City of Edmonton, Alberta, Canada

THE city of Edmonton, situated in the central northern portion of the province of Alberta, Canada, has grown in recent years to a population of approximately 16,000 and become an important station among the coal-producing centres of Western Canada. Three railroads offer to the city of Edmonton good shipping and transportation facilities, and at the present time real estate is high and conditions there are very prosperous.

In the expansion which has, of late years, taken place there the municipal lighting and power plant for Edmonton has been outgrown, and the initial equipment, which comprises Allis-Chalmers electric generators driven from high-speed engines, will soon be supplemented by a new plant in which gas power will be used, the first installation consisting of one 700-KW gas engine and alternator, the former to operate on producer gas.

The engine is of the standard horizontal twin tandem type built by the Allis-Chalmers Company, and consequently it has all the refinements of the latest practice in gas engine design. The speed of this engine is 150 revolutions per minute. The piston rods are water-cooled, water being introduced at the centre slide, with a discharge in the crosshead for the front piston and a discharge in the tail guide for the rear piston, each piston having its separate supply.

The unit has four cylinders 24 inches in diameter by 32 inches stroke, and uses gas of 130 effective British thermal units. In the air starting system provided for the engine air will be admitted to each cylinder, in turn, at what would be the explosion stroke. The high compression carried prevents the engine from stopping on dead centre, which arrangement insures proper starting of the engine from any position without the use of a barring gear. The motor-driven air compressor, also furnished by the Allis-Chalmers Company, has a capacity of 36 cubic feet of free air per minute, compressing to 200 pounds per square inch into two air tanks.

The generator, which follows the well-known Allis-Chalmers design, is rated at 700 KW. and wound for 2,300 volts, 60-cycle, three-phase. The generator is excited by means of a 50-KW. gas engine-driven unit, also built by the Allis-Chalmers Company.

Allis-Chalmers Company, Machinery Specialists

THESE are the days of the specialist, whether it be in medicine, law or manufacturing. In order for an individual or a company to keep abreast of the times and to prosper, it is necessary to reduce the production of his commodity to a state of such efficiency that it will be recognized as "standard" and the demand for it thereby increased.

The specialist is ordinarily thought of as one who confines himself to one or a few related lines and is content to master them. It is perfectly reasonable, however, that a group of manufacturing specialists, each the master of certain products, may become so associated under a single directing influence as to form a single company out of many elements, each one of which may continue to turn out a perfect product.

Allis-Chalmers Company, whose works comprise seven different plants, located in leading commercial centres of the country, and whose output is comprised in eleven distinct departments of manufacture, is, in the mind of the interested visitor at any of its works, a typical example of the engineering and manufacturing specialist mentioned above.

The units or departments of the Allis-Chalmers organization are as follows:—Electrical, steam engine and steam turbine, gas engine, hydraulic turbine, air brake, crushing and cement machinery, flour mill,

mining machinery, pumping engine, sawmill, each of which has its own manager, who is in charge of its sales and engineering activity. In addition, each department has its own correspondents, engineers, order department and separate works organization. At least three of these departments have entire works devoted to the manufacture of their products. They comprise the electrical works at Cincinnati, where Allis-Chalmers electrical machinery (with the exception noted below) is built; Chicago Works No. 1, where Allis-Chalmers mining, smelting and refining machinery of all kinds is built, and Chicago Works No. 2, where Gates rock and ore breakers and all Allis-Chalmers cement-making machinery is built. The sawmill and flour mill departments divide the output of the Reliance Works at Milwaukee, and at the mammoth West Allis, Milwaukee, Works are built heavy electrical machinery, steam engines, rolling mill engines, pumping engines, steam turbines, gas engines and air brakes.

Allis-Chalmers Company is a true specialist in each one of these lines, carried along entirely independently of the others. Experts give their entire attention to the details of department engineering. Even in the progress of these products through the works is the segregation maintained, so that, in effect, each one is designed and built as a specialty by a corps of experts accustomed to produce that line alone.

The works at West Allis, the newest and most interesting to the visitor of the company's plants, were laid out with special reference to this unit organization. Six large machine shops, each 580 feet long, are devoted to the special production of machinery, as follows:—Shops Nos. 1 and 2 are devoted to the building of steam engines of all kinds; in Shop No. 3 forgings are made; No. 4 is devoted to the building of steam turbines, No. 5 to gas engines, and No. 6 has two upper floors devoted to air brakes and the remaining space to the building of heavy electrical apparatus used in direct-connected units.

It is only necessary for the visitor to glance at the records made by its products in actual service to learn how thoroughly Allis-Chalmers Company has specialized. Allis-Chalmers engines, into the thousands, are standards everywhere for all classes of service. Gates breakers and Allis-Chalmers cement making machinery have been pioneers for thirty years and have maintained their prestige to the present time. Allis-Chalmers mining machinery is recognized everywhere as the best.

Allis-Chalmers sawmill machinery cuts more timber every year than that of all other builders, and Allis-Chalmers flour mills, the first to be designed after the modern roller type, grind more wheat than those of any other builder.

Allis-Chalmers electrical machinery is favourably known everywhere for long service and high efficiency. More Christensen air brakes are used on electric systems throughout the country than all other makes combined. Allis-Chalmers hydraulic turbines represent the best results of European and American practice. Allis-Chalmers gas engines now on order and under construction have an aggregate value into the millions.

Allis-Chalmers steam turbines are every day earning for themselves new friends and good repute for their builders. Over sixty units are in operation or building, and in all cases their performance has been remarkable for its excellence.

Not only has Allis-Chalmers Company made specialties of all its lines of manufacture, but it has maintained them in the lead against years of competition.

"It Gives Back All the Change"

WE probably quite generally appreciate the happy catch phrases which become so familiar and which so jauntily carry the ideas which make things go in the world of advertising. Some of them have been carefully and labouriously moulded for their special missions; a common belief, however, is that the best of them have had an apparently fortuitous origin. Their apt suggestiveness or their facility of catching and holding have often been realized afterwards rather than at the instant of their first putting forth.

The better phrase really, and the one ultimately the most telling and successful, is that which suggests some actual and special characteristic or property pertaining to the individual thing spoken of. "It gives back all the change," as above, carries a positive statement concerning a certain pumping system, and at the same time implies, or practically asserts, that other systems do not give back all the change, or do absorb, dissipate or in some way take more than the power actually requisite for the work and which ought to be expended for it. The phrase thus truthfully and very intelligibly carries both high commendation and severe condemnation. How, if preventable, is mechanical dishonesty any more justifiable than financial dishonesty?

"It gives back all the change" is used as specially applicable to the return-air system of pumping water, and the analogy suggested is well sustained throughout. The operation of elevating water by the expenditure of power, the power being applied either directly or intermediately, is quite similar to the purchasing of goods in the market by the expenditure of money. There is a price which is just and right for anything man may buy, and, similarly, there is also and always a certain expenditure of power which would be exactly right for raising any quantity of water to any given height.

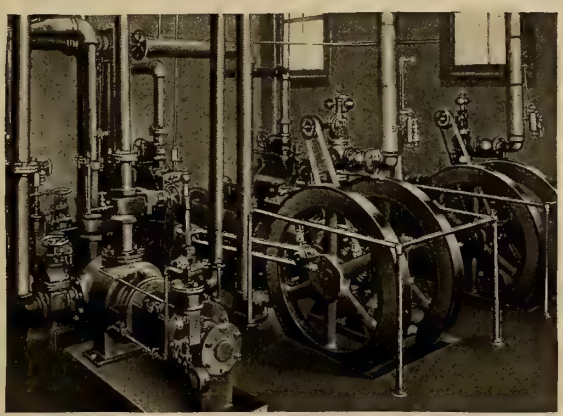
We do not have to go far to find the systems of water raising which do not give back all, or indeed any, of the change, for such systems are most familiar. We speak here particularly of the devices which use compressed air as the medium, the air compressed and used representing the power cost of its compression, just as silver or gold represents the labor cost of their production. In the case of the direct displacement pump we have first a tankful of water which is to be expelled and driven up through a pipe to the point of delivery. Compressed air is accordingly admitted at sufficient pressure to expel the water, and when the water is thus expelled the tank is full of the air at its full pressure.

We may now imagine the tank to be an engine cylinder with a moving piston, which at the moment is somewhere in the first half of its stroke and at the precise point where cut-off occurs. The end of the cylinder up to the piston is filled with full-pressure air, and this volume of air is the total air expenditure for that engine stroke. In the case of the water tank this volume of air has done all the work that it will be permitted to do, and it is at once discharged. In the case of the engine the equal volume of air, instead of being discharged, continues to do work by driving the piston to the end of its stroke, all the work so done in addition being the change which the direct displacement pump failed to utilize or to return any equivalent for. In the return-air pump the work of expelling the water from the tank is quite similar to the work of the direct displacement pump, but after that the returning of the change occurs, the air, instead of being discharged, being turned into the intake pipe of the compressor, and in its expansion helps to drive the compressor or to repay the cost of the original compression. This thus told is a simple enough device, but it represents mechanical honesty and profit.

THE INGERSOLL-RAND

"RETURN-AIR" PUMPING SYSTEM

The Most Economical Method of Pumping by Compressed Air



The high economy of this system is due to the fact that the air, after compression, is not exhausted, but is expanded and recompressed, this expansion doing part of the work. No working parts are in contact with the liquid pumped, **hence this high economy is maintained indefinitely.**

"RETURN-AIR" Installation at the Chattanooga Furnaces of the Chattanooga Coal and Iron, Chattanooga, Tenn. This illustration shows the air compressor end and the automatic switch of the system.

The system is automatic in operation, is easily installed, is adapted to any lift or capacity. It pumps any fluid without injury—clear, muddy, gritty or acid water, acids, solutions, sand or marl. It does work which no other pumping system can successfully handle.

Pumping sand with the "RETURN-AIR" System in the quarries of the United States Silica Co., Ottawa, Ill. This illustration shows the tank end of the system which is usually submerged when pumping liquids.

INGERSOLL-RAND CO.

11 Broadway, New York

Chicago	Philadelphia	St. Louis
Cleveland	Butte	Pittsburg
El Paso	Birmingham	Boston
Houghton	Denver	San Francisco
Seattle	Los Angeles	Salt Lake
Mexico City	London	Melbourne
Paris	Johannesburg	Berlin

V28

The Equipment of the Boiler Room

IN the modern engineering establishment the aim of the competent manager is to obtain the highest efficiency at the lowest cost, to make savings in the total expenditure, and thus to avoid unnecessary expense as compared with the output.

Until recently certain departments of an establishment were developed in advance of other portions, and too often the sections which were most in evidence received the greater share of attention. This defect, however, is now being overcome, and the foundry, the boiler room, and other important departments are beginning to be cared for, as well as the engine room and the machine shop.

It has been estimated that in a power plant somewhat less than one-half of the total expense of operation is required for fuel, from which it may be inferred that economy and efficiency in the operating department is at least as important as economy in the actual combustion of the coal. This means that the handling of the fuel, the removal of the ashes, the maintenance of auxiliaries, and all the details which go to make up the complete boiler room, demand as much and as careful attention as the coal bill.

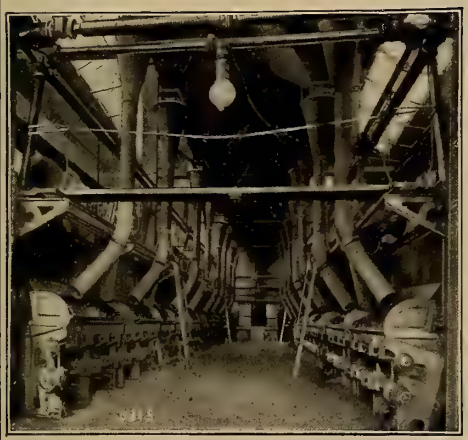
Especially is it important that mechanical aids be given in all the laborious work which need not be performed by manual labour. There is no doubt that in a well equipped boiler room the working force may be reduced to one-half, or less than needed when all the laborious work is performed by hand. If the coal is received and conveyed mechanically to overhead bins, from which it may descend by gravity through controlled weighing chutes to the mechanical stokers, the economy in labour will soon pay for the cost of installation, after which the expense of operation is reduced correspondingly. In like manner the removal of ashes by mechanical means dispenses with one of the most laborious and severe elements in boiler-room work, work which it is entirely unnecessary to have performed by hand.

An important element in an orderly boiler room appears in the floor, and too often a boiler-room floor appears broken and irregular, unfit to belong to a well-conducted shop. In establishments where the industrial railway and cars form a portion of the equipment the floor is sometimes wholly covered with cast-iron floor plates, these being similar in construction to the plates forming a portion of the industrial railway in the shop or elsewhere when a flush surface is desired. There is probably no better floor for a boiler room than cast-iron plates imbedded in cement, the roughened surface giving an excellent foothold, while the durability and freedom from repairs make the cost of maintenance a minimum.

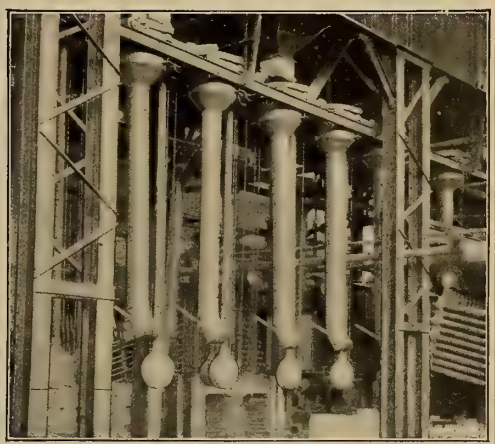
Such a floor should have the side plates provided with the edge next to the wall turned up in such a manner as to provide a concave fillet instead of a sharp angle, this simple plan rendering it easy to keep the edge of the floor clean and free from dirt. A similar plan may be followed when the floor is made of concrete, but concrete floors are apt to become damaged and broken when heavy tools are dropped on them, and when once broken they are difficult to maintain in repair.

When it is considered that a boiler room is a place through which coal and water pass in an almost continuous flow, the former being burned to gases in order to convert the latter into steam, there appears no very good reason why there should be an accumulation of coal or dirt or ashes than there should be puddles of water or slop and leakage of steam. Both such defects indicate waste and poor economy; their absence, on the contrary, may be taken as indications of efficient operation, both of materials and of men.

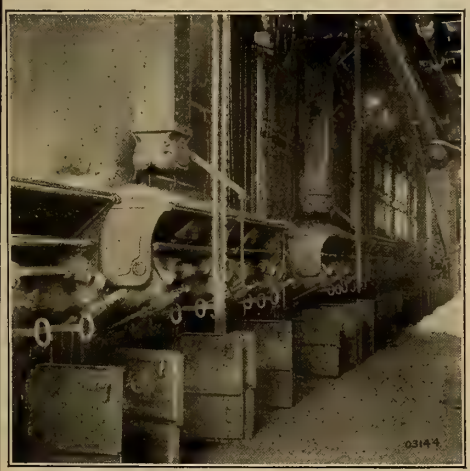
Boiler Room Equipments



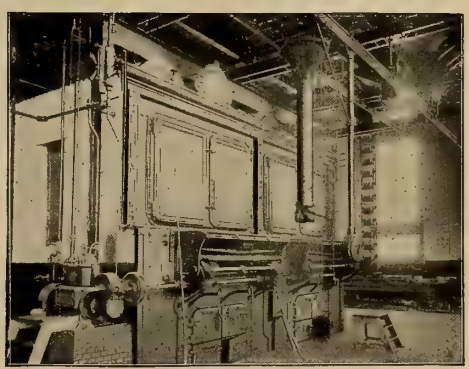
No 0315. The overhead hoppers are shown, from which coal is supplied to the automatic stokers through two-way chutes.



No. 03138. Hunt weighing hoppers and scales are shown in this illustration, twenty of which are in use at this plant.



No. 03144. Coal is supplied to the automatic stokers through chutes, the quantity being regulated by Hunt duplex cut-off valves.



No. 03140. A complete boiler room equipment, including conveyer, weighing scales and hopper, are shown in the above illustration.

For use in small boiler rooms, we make special cars, trolleys, etc., for operating by hand power.
Send for a copy of our Coal Handling Machinery Catalogue.

C. W. HUNT COMPANY

ESTABLISHED 1872

Works and Office, - West New Brighton, Staten Island, New York.

NEW YORK OFFICE: 45 BROADWAY.

Electric Hoists on Traveling Cranes

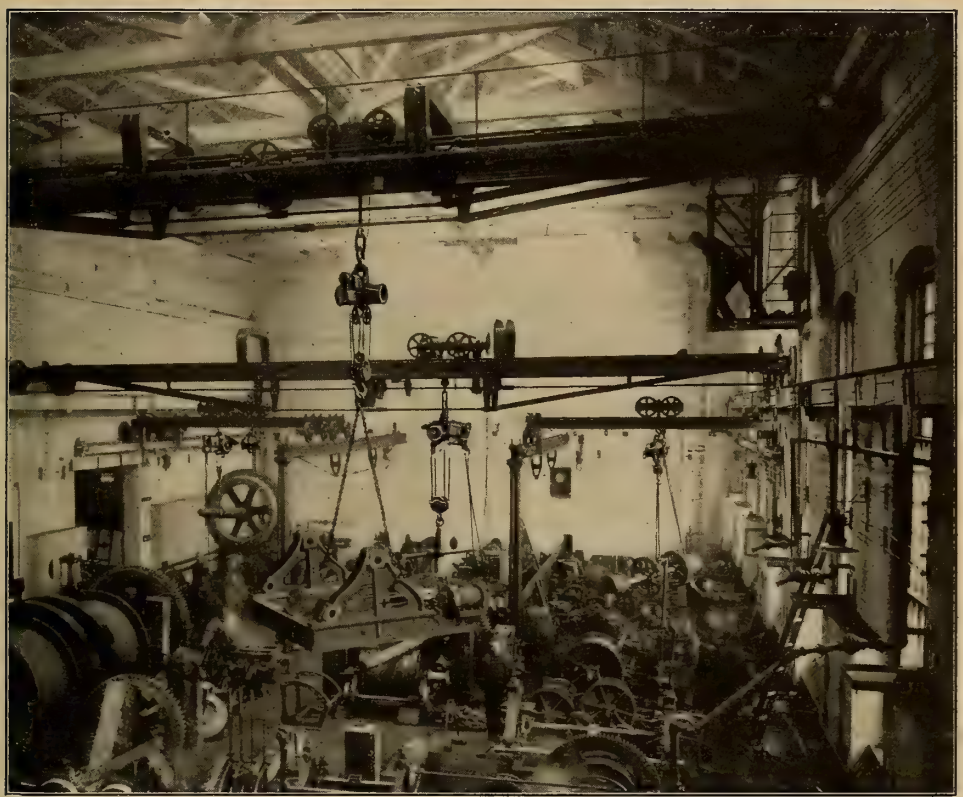
IN the course of the development of the electric power traveling crane from the older hand machine there has resulted a highly organized and most effective piece of mechanism. In many shops, however, the conditions do not admit of the removal of the older hand-traveling cranes and the installation of the more expensive machine, and in such cases many managers are content to jog along in the old way, simply because they do not know how to make the desired improvement within the limit of cost available or warranted by the work to be done.

The principal effort to be exerted, in most cases, is that required for hoisting, since an ordinary hand-gear will suffice for bridge travel, while the trolley can be moved along on the bridge simply by pulling upon the load, and this suggests the simplest method of converting an old-fashioned hand traveling crane into what may be termed a semi-power crane. It is only necessary to suspend an electric hoist from the trolley and make the necessary electrical connections, and a power lift is secured at a minimum of expense. If there is sufficient head-room for the purposes of the shop the electric hoist may be attached merely by a link to the original hook of the trolley, while if the full height under the bridge is required for hoist the electric hoist can be attached higher up in the trolley, this detail varying according to local conditions.

In some instances, however, a more complete machine is needed, and it then becomes necessary to place an electric motor on the bridge, to provide for its travel, and to put an electrically-propelled trolley on the bridge and attach a cage for the operator. Since a commercial electric hoist is still available for the hoisting operation, however, such a conversion may be effected at a much lower cost than would be required to install a new electric power crane of the same capacity, while the saving in the time required for the change must also be considered. The machinery needed for the bridge travel is very simple, and when the trolley does not have to contain the hoisting machinery its cost is also greatly reduced. The independent electric hoist fulfills all the purposes which would be effected by a hoisting drum and its motor and mechanism built into a trolley, and, being a regular market product, the cost is materially lower than would be the case with this portion of a complete power crane.

It does not follow that such combinations are desirable for situations in which the entire handling plant is designed as a portion of the equipment of a new shop, or for heavy and continuously severe service; but there are so many instances in which the growth of business renders changes in older portions of an establishment necessary that the electric hoist becomes applicable. Thus, such a conversion may be found desirable in the application of a room to other purposes for which it was originally equipped. A warehouse or storeroom may have been provided with a simple hand traveler, ample for handling the goods stored therein, and the pressure of and expanding business renders it desirable to use the space for manufacturing. The conditions would not warrant the installation of an expensive power crane, and yet the old machine is inadequate. The cheap, powerful and convenient electric hoist here comes in to enable the service to be given at a minimum of expense, and, what is generally as important in such an emergency, with practically no delay.

In this connection it is well to remember that a well-built electric hoist may be used occasionally to handle loads much greater than its rated capacity if operated slowly and carefully, so that the nature of the service should always be considered in arranging such installations.



Here are four 2-ton and one 6-ton Y & T portable electric hoists installed on traveling cranes in the erecting shop of the Lidgerwood Mfg. Co., Brooklyn. The four 2-ton hoists are controlled from the floor, while the 6-ton

Yale & Towne Electric Hoist

is operated from the cage. This 6-ton hoist was installed on an old hand crane. The total cost, including remodeling of crane, cost of hoist, etc., was less than $1,000.00, while a regular electric crane to handle the same work would cost at least $3,500.00. There is also a decided saving in cost of maintenance.

¶ *We make the most complete line of portable electric hoists and chain blocks. They will save money on your work Write for catalogs and prices.*

The Yale & Towne Manufacturing Co.

9 Murray Street, New York

Foreign Warehouses—Fairbanks Co., London & Hamburg; Fenwick, Freres & Co., Paris; Alfred H. Schütte, Köln a Rh.; F. W. Horne, Yokohama, Japan.

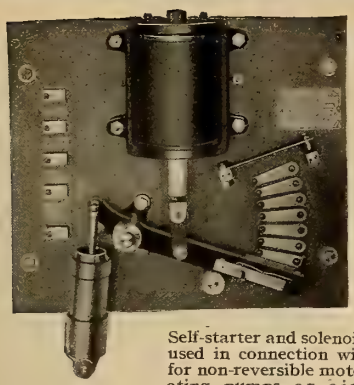
The Electric Control of Power Machinery

APART from the general convenience of electric power, and the opportunities which it affords in the placing of machinery in the most advantageous positions for efficient operation, one of the most important changes which its introduction has wrought lies in the convenience of control which it permits. The machine designer had formerly to consider most carefully the placing of the various levers, hand-wheels and other appliances by which the operator controlled the apparatus. Handles had to be brought out at points convenient to the position of the workman; exposure to heat or to moving portions of the machine had to be considered, and sometimes the commercial success of a machine depended very largely upon the care which had been given to those elements involved in the convenience of control. With the introduction of electric power, however, it became possible so to arrange the working parts of an installation that they could perform their work to the best mechanical advantage, since the question of control was a matter which could be settled afterwards, and which was practically independent of the position of the working parts.

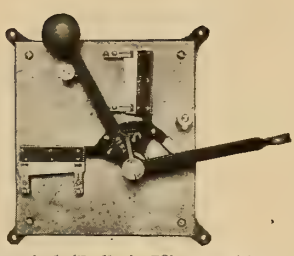
An example of this independence of control is seen in a comparison between an electric car and a locomotive engine. In the latter machine it is necessary to provide a strong reversing lever, connected to the link motion by a heavy bar. To this must be added the valve lever, this being brought over to the side of the cab, so that both handles may be close to the point where the engineer stands. In like manner, mechanical connections for all the functions of the machine are gathered about the same operative point, as the outcome of experience in the design of a machine which is the product of the thought of many designers. With the electric car all these mechanical connecting appliances are omitted. The motors are placed where they can best be connected to the wheels, the wiring is brought to the platform or cabin for the motorman, and all the functions of control are included in a single, separate piece of apparatus, which, with its single handle, enables the operator to manage all the movements of the vehicle. In like manner the operations of an electric travelling crane are managed by a controller which enables all the varied functions to be determined from the operator's cage, and all electrical machinery may be similarly controlled.

But the facility of electrical control extends much further. Practically every kind of machine in which the operations are directed by mechanical connections may have those movements effected by electric motors, and since these can be managed in turn by electric controllers, the field for such apparatus is practically unlimited. Printing presses, elevators, pumps, air compressors, cranes, hoists, machine tools of all kinds, for these the modern system of electric control appears as the one effective method of handling and direction.

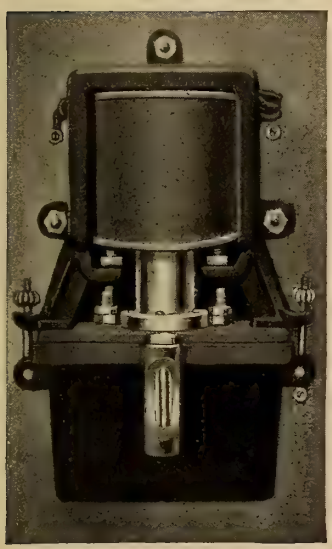
Under the modern method of differentiation of industrial operations the separation of the control from the machine and its embodiment in an independent device has naturally led to the specialization of the manufacture of such apparatus. Thus, the larger and heavier pieces of electrical machinery, dynamos, motors, transformers, converters, etc., are manufactured by establishments which prefer to leave the production of switchboards, starters, regulators, controllers and similar appliances to firms which, by devoting their entire attention to this department of work, may bring these devices to a degree of perfection not otherwise attainable, and at the same time develop methods of manufacture which bring the costs within the necessary commercial limits.



Self-starter and solenoid switch used in connection with same for non-reversible motors operating pumps or air compressors. (Bulletin 70.)



Float switch (Bulletin 73). Used in connection with Bulletin 70 self-starter in open tank systems on D. C. circuits.



Self-starter for alternating current motor. (Bulletin 22.)

Gauge type pressure regulator (Bulletin 71). Used in connection with Bulletin 33 and Bulletin 70 self-starters in closed tank systems.

Pumping Problems

THOSE INTERESTED in the subject of automatic pump control, will find the Bulletins descriptive of apparatus illustrated on this page useful for reference. Cutler-Hammer controlling devices for motor-driven pumps are designed for both alternating and direct current circuits.

Cutler-Hammer controlling devices cover the whole field of electric control. We make controllers for electrically-operated printing presses, elevators, machine tools, cranes and hoists, etc. Also starting rheostats, speed regulators, self-starters, dynamo field regulators, battery charging rheostats and theater dimmers. Bulletins descriptive of any line of apparatus mailed free on request.

THE CUTLER-HAMMER MFG. CO.

MILWAUKEE, WISCONSIN

NEW YORK OFFICE:
136 LIBERTY STREET

CHICAGO OFFICE:
MONADNOCK BLOCK

BOSTON OFFICE:
176 FEDERAL STREET

PITTSBURG OFFICE:
FARMERS' BANK BLDG.

THE LATEST CATALOGUES

Hydraulic Presses

THE WATSON-STILLMAN CO., New York.—Catalogue No. 70, relating especially to hydraulic forcing presses as applied to the making or breaking of forced fits in the assembling or separating of machinery. Presses for bolts, mandrels, crank-pins, car wheels, and general shop purposes, are illustrated, as well as powerful machines for forcing together the parts of electric generating sets. Among the special presses illustrated are machines for forcing the journals into sugar rolls, with capacity of 600 tons, also projectile banding presses, and similar machines, the whole list forming a very complete line of valuable tools of the highest class.

Catalogue No. 72, illustrating and describing turbine pumps of the Twinvolute design, both simple and multiple stage, for various heads and capacities. Comparative illustrations are given, showing the effective arrangement of the guides and impellers of the Twinvolute pump, and also the arrangement for its operation by alternating or direct-current electric motors. The catalogue contains a number of useful tables relating to the handling of water by pumps.

Grinding

NORTON GRINDING CO., Worcester, Mass.—Catalogue No. 7, illustrating a very complete line of machines for plain cylindrical grinding. These machines are used for straight and taper work which revolves upon two dead centres, the work being turned roughly and then ground accurately to size. The line of grinders includes machines up to 18 by 168 inches, as well as special car-wheel grinders and machines for grinding the crankshafts of automobiles. Illustrations of examples of grinding are appended, showing the material gain in time by using only a roughing cut in the lathe and employing the grinding machine for finishing, while the superior accuracy of the ground pieces is emphasized.

Paint

SEMET-SOLVAY CO., Syracuse, N. Y.—Pamphlet relating to Chrysolite paint, a protective material for use on corrugated iron buildings, metal roofs, steel stacks, storage tanks, etc. This paint is the result of the effort of the technical staff of the Semet-Solvay Company to find a protective material for the buildings of its own works, and it is also offered as a commercial material to the trade and to manufacturers. The paint is especially adapted to resist the action of acids and to prevent corrosion by salt water and other substances.

Pyrometers

WILLIAM H. BRISTOL, New York City.—Catalogue of electric pyrometers for indicating, recording and controlling high temperatures, and adapted to every-day practice in industrial works, manufacturing plants and laboratories. A general description of the pyrometer, with reproductions of records of temperatures for blast-furnaces gases, hot-blast of furnaces, temperatures of lead baths, etc.

Chain Belts

CHAIN-BELT CO., Milwaukee, Wis.—General Catalogue No. 35, a substantially bound book, very fully illustrated with applications of chain belts for elevating, conveying and power transmitting machinery. A full line of sizes of chain links are shown, together with sprockets and auxiliary apparatus.

Packing

THE UNITED STATES METALLIC PACKING CO., Philadelphia, Pa.—Small catalogue of metallic packings for piston rods, valve stems, etc., for stationary and marine steam engines and for gas engines. Sections of stuffing boxes are given, showing the arrangement of the packing, as well as the recommended method of lubrication.

SMITHSONIAN INSTITUTION LIBRARIES
3 9088 01630 7837